

THE
SOUTH ITALIAN VOLCANOES

BEING THE ACCOUNT OF AN EXCURSION TO THEM
MADE BY ENGLISH AND OTHER GEOLOGISTS IN 1889
UNDER THE AUSPICES OF THE

GEOLOGISTS' ASSOCIATION OF LONDON

WITH PAPERS ON THE DIFFERENT LOCALITIES

BY

MESSRS. JOHNSTON-LAVIS, PLATANIA, SAMBON, ZEZI
and Madame ANTONIA LAVIS

INCLUDING

THE BIBLIOGRAPHY OF THE VOLCANIC DISTRICTS

AND 16 PLATES

EDITED BY

H. J. JOHNSTON-LAVIS

M. D., M. R. C. S., B.ÆS Sc., F. G. S., etc.



NAPLES

F. FURCHHEIM, 59, PIAZZA DEI MARTIRI
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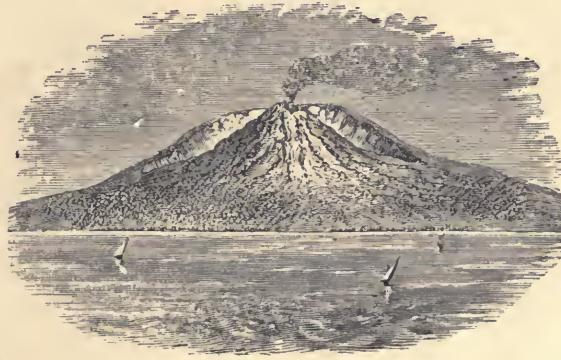
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Printed by FERRANTE Vico Tiratoio, 25 — Naples

P R E F A C E

The British Isles, as every geologist knows , fortunately or unfortunately according to the way the question is viewed, possess no active or even recently extinct volcanoes, nor are our islands often convulsed by earthquakes. Nevertheless, Englishmen stand pre-eminent as vulcanologists and seismologists — as the names of Daubeny, Scrope, Lyell, Geikie and Judd amongst the former and Mallet , Milne , Ewing and Gray may amongst the latter be taken as admirable examples. Of late years British geologists have tended to neglect recent volcanoes, both as to investigating their so far unexplained phenomena or making themselves acquainted with those already known, often not even with their principal features. In fact we have but to read many of the papers on the older volcanic deposits of our country to be struck with the little practical acquaintance of the writers with characteristics of active fire vents , but who yet endeavour to unravel the history and phenomena of igneous rocks , that have been subjected to inestimable modifications since they came into existence.

It is my lot to see year after year pass by with comparatively few English geologists or students visiting this region of active and recent volcanoes, whilst numerous German, Austrian and American geologists or students pay honour to the forges of Vulcan. In 1888 at the Delegates dinner at the Brit. Association meeting of Bath, to which I had been kindly invited, I suggested that a big field excursion to the south Italian volcanic region should be made , and expressed a desire that the different societies, then represented, should take part in it. Several objections were raised as to the season , length of excursion , etc. but the idea in general was favourably accepted and I was asked to take the necessary steps to organise it locally in Naples , whilst the Geologists' Association of London took the initiative in Great

Britain. Everything went smoothley at first but later proper notice was not given to the other societies, the travelling arrangements were delayed to a useless date and the excursion secretary in London, who was to have acted as administrator, some three days previous to the start from England, became invisible. In Naples a local committee had been formed, which had made all the necessary arrangements with the Minister of Public Instruction, Comm. Boselli, who took much interest in the excursion, the Minister of Posts and Telegraphs, the railway companies, and a steam ship had been retained, but could not be contracted for till the number of the excursionists was sent from London. Unfortunately this advice never came, the steamer could only be chartered on the arrival of the party in Naples, resulting in the notice being too short to get the ship fit for comfortable accomodation, Besides the general as well as a large portion of the scientific direction, I suddenly had heaped upon my shoulders the no light burden of the administrative department, in consequence of the absence of the excursion secretary. Fortunately Dr. L. Sambon the active local secretary was a most valuable aid in fulfilling the latter office and had it not been for him I fear the trip would have been a failure.

It must be remembered that to take a party of 50 or more through southern Italy and especially the Lipari islands, Etna and Roccamonfina is a very serious matter and can in no way be compared to a similar trip in the British Isles. The excursion was not one of half or one day, or even a week, but of six weeks amongst some of the most unbusiness-like people of Europe. Notwithstanding all these difficulties, the undertaking proved to be a higly successful one and even the very few well known habitual grumblers, later on admitted they had thoroughly enjoyed themselves. No severe illness, no grave accident or misfortune of any kind occurred to the party, although we visited regions considered by authorities who know the want of every necessity and comfort as an act of serious risk.

That the excursion has already commenced to bring forth some fruit is shown by several papers on the region that have appeared from the pens of some of the party, and by others now in preparation.

Much of the success is also due to the extremely kind way in which the public authorities did everything they could to facilitate our undertaking, as likewise several private individuals, and this opportunity is taken to thank them in our names as well as in those of the excursionists who owe so much to them.

A list of these benefactors we append at the end of this preface. Besides these we are grateful for several invitations from different local authorities and persons to visit their interesting regions but which we were obliged to decline with regret, on account of our already overcharged program.

It was the hope of the editor to have had short and concise articles from each special director, and most had promised and have repeated their promises; although eighteen months have passed some have not been fulfilled and this volume has been closed, after months of delay.

The sad premature death of Prof. O. Silvestri, who had been such an instructive guide and kind colleague, but a few months after the excursion must be deeply regretted by all those who had the pleasure and benefit of his direction. He had promised a long chapter on Etna but only a few pages had been written when he was cut off from further work.

Another cause of delay was the bibliographical list which entailed an amount of labour that few can conceive except those that have worked at it, but it is hoped that its value will be appreciated.

THE
GEOLOGISTS' ASSOCIATION AND OTHER EXCURSIONISTS
EXPRESS THEIR DEEP GRATITUDE
FOR
HOSPITALITY, HELP, AND KINDNESS
RENDERED BY THE

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CHAPTER I.

THE ROUND TRIP
IN DETAIL

BY

DR. JOHNSTON-LAVIS

EXCURSION TO THE SOUTH ITALIAN VOLCANOES.

By H. J. JOHNSTON-LAVIS, M.D., F.G.S.

(Read January 3rd, 1890.)

On Tuesday, September 17th, at Messina, the son of the late Prof. Seguenza and Messrs. Platania, of Acireale, met the party, and acted as directors. The steep escarpment of Taormina, composed of Triassic and Liassic strata, which have given rise to much controversy, was examined in the walk up to the town from the station.

Early the next morning the members of the excursion returned by train to Messina, to embark on the "Villa San Giovanni," a small private steamer hired for the week's trip to the Lipari islands. Just after mid-day we steamed out of the harbour and through the Straits, obtaining a splendid view of Seilla, with the lofty triple-stepped mountain of Aspromonte, which probably owes its configuration to as many planes of marine denudation. The port of Lipari was reached at sunset, when some of the less seaworthy members landed to pass the night. A portion of the party walked to the south end of the island to watch the explosions from Vulcano, and were repaid by seeing one dust-cloud give out many flashes of lightning. The next morning (September 19th), weather being favourable, we steamed out soon after sunrise and reached Stromboli early in the forenoon, where the ascent was made on the east side of the Sciarra. The summit was reached by a climb of about three hours, with short interruptions during which the party helped themselves to the splendid grapes from the vines through which much of the track lay. At the top I pointed out the sites of one or more ancient craters, as well as the peculiar position of the present vent, which occupies a situation similar to that of a parasitic cone, at a high elevation, but yet a considerable distance below the mountain summit. On account of the great depth of the sea at the north foot of the island, all the ejected materials that cannot remain at their maximum angle of repose roll down to the sea and continue their course onwards to the submarine foot of the cone. Five of the party photographed the crater from the overhanging summit. There were five active blow-holes, or small vents and cones, each of which from

time to time ejected with considerable violence showers of hot, pasty lava fragments, often accompanied by splendid vortex rings of smoke. The party then descended to the level of the vents on the west side of the Sciarra, from which also a fine view and many photographs were obtained. The westernmost vent showed a small quantity of pasty lava oozing from it for a metre or two, and then breaking off in pieces, which bounded down the steep slope of the Sciarra to the sea. Many augite crystals were collected, and the party then descended over a steep talus of sand and winding paths to the town, and embarked on the steamer. The ship steamed round opposite the Sciarra, where, two hours after dark, the monotony of the peculiarly hard bread (compared by some to trachyte) was relieved by the splendid display of Nature's fireworks.

At daybreak we steamed for the islets of Basiluzzo, Datolo Lisca Bianca, Lisca Nera, and Bottaro, on some of which a landing was made, and a few of the members attempted to see the Caldaje, a well-known submarine fumarole, but owing to the roughness of the sea its exact position could not be made out. The party then landed on Panaria, where the typical liparite is seen to perfection. There I drew the attention of the members to the very large number of worked obsidian flakes which are met with in the surface soil, though no natural source of this rock occurs at the island. These, together with numerous little Greek statuettes of household gods, indicate the colonization of this island in very early times. On a visit to Lisca Bianca also, some years since, I found a small number of obsidian flakes on that island. At Panaria the party collected a considerable number of flakes and a few implements.* The same evening the port of Lipari was reached, and as the steamer coasted along

* From the house top on Panaria, where the party had breakfasted, a fine view of the neighbouring islets could be obtained. I drew attention to the fact that Panaria, Basiluzzo, and the other islets constituted a volcanic pile, chiefly submarine but which in many respects might be compared to Lipari itself. In fact, were the sea bottom raised a few fathoms, an island of very considerable extent would be formed, the higher eminences of which would be constituted by the few patches of dry land we saw before us. Panaria and Basiluzzo represented two enormous domes of a highly acid trachyte or rhyolite or liparite, as variously named, which had oozed forth in a highly pasty condition without much explosive action. Some portions of the magma were less glassy than others, and as these had been drawn out just as the layers of butter and dough in a flaky pie-crust, they had produced a similar stratified structure at these two islands. If you compare the appearance of the natural section of Basiluzzo with the artificial experiment of Prof. Leyer ('Theoretische Geologie,' Stuttgart, 1888, Fig. 153, p. 152, copied into Prof. Judd's 'Volcanoes,' Fig. 43, p. 126) you will notice the striking resem-

the east coast of that island those on board were able to examine the principal geological features as they were pointed out to them. From north to south these are the great white crater of explosion of Campo Bianco, and the enormous obsidian stream that afterwards welled out from it, breaching it to the north-east, and flowing down into the sea, now known as the Rocche Rosse and Punta della Castagna. The far greater height of the south wall of the crater, with its peculiar hump, now known as Monte Pelato, I pointed out as due to the explosion occurring on the side of an old dolerite cone, which, covered by the essential ejectamenta of the Campo Bianco crater, constitutes this Monte Pelato. This structure is revealed in the sea-cliff where the relations of the dolerite and white pumice are well seen. Farther to the south, the geologists were shown another obsidian stream which issued on the east side of Mte. St. Angelo, and flowed nearly down to Canneto. The next to attract attention were the twin cones of Monte Rosa and their peculiar imbricated slopes, due to the interstratifications of streams of dolerite with scoria and other fragmentary deposits, which were being undercut by the sea. Finally, the spherulitic rock upon which the Castle of Lipari was built, was also indicated.

A visit to the Island of Vulcano, which has been in a state of eruption since August 3rd, 1888, was the business of the next day. Landing at the Porto di Levante, the first thing that struck the attention of the party was Mr. Narlian's cutter with its side staved in by one of the projectiles at the beginning of the eruption, although the boat was more than a kilometre distant from the crater. The holes in the roof and walls of Mr. Narlian's villa, the desolation of the vine-plantation and broom scrubs, many of which had been kindled and burnt by the red-hot projectiles, and the deep layer of grey volcanic dust on everything, formed a striking picture of the desolation caused by a small eruption of a small volcano. As we approached the foot of the cone we were impressed by the projectiles scattered about in large numbers, many of which were of great size. One still hot, and therefore recently ejected, was about a cubic metre in size and

blance of the two. In fact, there is good reason to believe that important geographical changes have been brought about in historic times, and we have indisputable evidence of endogenous activity in the solfatara of Lisca Bianca and the fumarole of Le Caldaje.

nearly a kilometre in a straight line from the crater. Most of these bodies consist of a mass of very acid obsidian pumice, covered by a crust of obsidian, cracked and bent up in a very curious manner, which I have described elsewhere as *bread crust structure*.*

This I pointed out to be due to the obsidian reaching that intermediate stage between a liquid and a solid, or in other words a state of intense viscosity, like slightly warmed sealing-wax or hardened Canada balsam, which break when exposed to strong and violent mechanical stress, but bend under a slight and gradually applied one. The magma in the upper part of this volcanic chimney seems to be in this critical state, and, as the vapour collects and escapes from the more heated and fluid portion beneath the upper part, is broken in fragments and ejected, when it is relieved from the surrounding pressure and allowed to expand. The crust has cooled along the cracks before this, and continues to do so, as it is whirled through the air, and after its fall, whilst the interior expands at the same time, innumerable vesicles being formed from the water dissolved in the magma separating as steam. This expansion causes the cracking of the hardened crust, and in some cases protrusion through the crust. This expansion is proved not only by the cracking and protrusion, but also by the bending out in some cases of pieces of the crust and the drawing asunder of crystals, pieces of ancient dolerite and other rocks included in the magma, and attached to the walls of a vesicle.

The presence of these numerous projectiles, called "bombs" by some, was a warning; so the ascent to the crater was requested to be done in open order. After a tiring scramble, we reached its north-west edge. The old, deep crater is now replaced by a much shallower one, the sides and bottom of which are covered by obsidian dust, sand, lapillo, and projectiles of different kinds.

At the bottom we noticed a number of small, shallow, funnel-like pits in the sand, but no indication whatever of any activity, so much so that an unwary visitor might walk across it and probably notice nothing but a very high temperature. From time to time part or the whole of this crater-bottom is raised up by explosions of vapour and the essential eruptive material into

* H. J. J. L., "The Recent Eruption of Vulcano," "Nature," Vol. xxxix, p. 173, and "Further Notes on the Late Eruption at Vulcano Island," *ibid.*, Vol. xxxix, p. 109.

vast columns of dust, which rise to ten or more times the height of the volcano. Most of the coarser materials fall back into the crater, the distribution at a distance of the finer dust depending upon the force of the explosion and that of the wind.

During the greater of these explosions the bread-crust bombs are ejected to a considerable distance and electric discharges take place, which some of the party, who were fortunate enough to see one in the evening, described as having a peculiar green tint. We were able to remain at the crater's edge for two or more hours, during which upwards of a dozen explosions occurred, many of which five of us who were photographers have been able to register. We were at last driven away by a much more violent outburst, but on our way down did not fail to examine the fumaroles at the outer crater edge on the east side of the old obsidian stream. These were very active, giving out much vapour under pressure and depositing an abundance of realgar and sulphur and a little boracic acid.

The party then proceeded to the alum caves of the Faraglioni, whilst some bathed in the hot mineral streams gushing out on the shore close by, one well-known Professor of Mineralogy being very enthusiastic in collecting specimens of coquimbite, halotrichite, voltaite, and other rare alums in an exceedingly light Adamic costume, and fortunately for him no hand camera was in the vicinity. The triple-cratered doleritic cone of Vulcanello projecting from its plateau of lava, the formation of which has for the major part taken place in historic times, was next ascended and examined. As the different points were visited, the director explained the main features of interest, which will be reserved for a separate communication, they being too long to introduce here. After a very successful day the party embarked, with a rich collection of bombs, alums, and other specimens, on their return to Lipari, where the night was passed.

September 22nd was devoted to a trip on the Island of Lipari. Starting on mules and donkeys, we directed our steps to the east slope of Mte. St. Angelo, an old cone truncated by a crater of explosion. From the east side, at a very recent period, possibly historic, as the name would indicate, a stream of spherulitic obsidian oozed forth and flowed down the slope as a great, thick, viscous mass, known as the Forgia Vecchia reaching nearly to the beach. Comparatively little explosive

action seems to have preceded its outpouring. Over the actual vent are a few small craterets with diminutive rings of fragmentary material, which were formed towards the end of the eruption, and in one crater are the remains of the old gas-fissure from which the last emanations occurred, depositing on its walls haematite and granular fluorite. Quitting this point, the deposits of white pumice derived from the Campo Bianco crater begin to form a thicker and thicker covering as we approach that old eruptive centre. Soon the sunlit glittering snow-white flanks of Mte. Chirica stood looming out against the background of the blue sea. Here I was able to point out that these mountains, like the original Mte. Pelato, are dolerite cones simply covered with a mantle of white pumice, which in some points has been denuded off. A peculiar yellow band, representing an old vegetable soil, is here met with, dividing the upper white pumice of the Campo Bianco eruption from an older one of the same material, the point of origin of which is not clear without long and careful study of the intricate overlappings of different eruptive deposits.

The grand crater of Campo Bianco with its wall of white pumice deeply interested all the party. This locality, which supplies all the first-class pumice of the world, is drilled by thousands of tunnels made in search of the larger morsels. The valve depends on the practically total absence of any porphyritic crystals, which, from their greater hardness, would stand out and scratch the surface being polished. The view I offered of its formation was this:—Beneath this point there existed a fissure or canal filled by a completely fused acid glass in which separation of “formed material” in the shape of felspar or other crystals had not commenced. The glass in the upper part of the conduit had gradually dissolved or absorbed a considerable quantity of water from the more superficial and aquiferous strata until the increased tension was sufficient to overcome the superincumbent pressure. A gigantic explosion was the result, drilling out the side of the old dolerite cone of Mte. Pelato, the first essential eruptive material being nothing more than the scum or froth of the glass caused by the conversion of the water dissolved in it into the state of vapour on the relief of pressure, just as separation of carbon-dioxide blows out part of the champagne when the cork is removed. Behind there is, more and more gradually welled up, the less aquiferous glass which breached the crater to the north and poured forward into the

sea, forming a great promontory. The outer portion, which cooled more rapidly, remained a more or less pure obsidian, whilst the interior was able to undergo an imperfect crystallization, so that the whole mass has become an intricate spherulitic mass. As at the Forgia Vecchia, the last eruptive act is represented by the small unimportant crater-rings around the source and a few blow-hole craters. Some members made the ascent of Mte. Pelato along the crater edge, upon which a very large mass of black obsidian has been projected by one of the last explosions, which is interesting as showing the conversion of the fragments formed by its collision with the ground into bread-crust bombs.

A descent was made along the east side of the Rocche Rosse obsidian stream to the beach, where the deposits of commercial pumice-stone were examined, after which we embarked on our steamer, which had come to meet us, the mules returning by the paths.

The following day was devoted to the Island of Vulcano. Starting early from Lipari, we steamed along the east coast of Vulcano, landing just beyond the Pta. dell' Asino. The ascent to the great platform over the steep slopes was very tiring, as the track lay over the loose dust recently ejected, and nearly every broom, brush, or tree was dead or stripped of leaves, and the day a very hot and oppressive one. At the height of about 450m., we passed a notch in the crater rim near the Pta. della Trovatina, where ancient, very finely stratified, dust beds are seen to perfection, traversed by an old radial dyke. Just beyond this point we rested in the shade of a few still surviving broom trees, and obtained a number of photographs of the explosions from Vulcano. Thence we proceeded to a small farmhouse, where a few grapes that had been able to resist the destructive effect of the falling volcanic dust were very acceptable. Close by I drew the attention of the party to a group of small olivine-basalt cones, La Sonnata, where a number of beautiful, fusiform bombs and pieces of finely corded lavas were collected. This was a good point to give a general outline of the structure of the island, so far as two short visits have permitted me to make it out, and as it differs from the very simple arrangement we read of in text-books, it is perhaps worth repeating.

At a distant period two great cones grew up, that to the north-west of a line from So. dell' Arpa to Mte. Luccio being composed of trachytic rocks, and that to the south-east of

doleritic rocks. Which of these came first it is difficult to determine without a very detailed study, and it is not unlikely that they were contemporaneous, as Vulcanello and the present active cone of Vulcano have been. One or more grand explosive eruptions then truncated somewhat eccentrically to the north-west the great dolerite cone of the south half of the island. At a later date, one or more explosive eruptions likewise truncated the trachytic cone of the north half of the island somewhat eccentrically to the north-north-east of the original axis. Much of the filling up and conversion of the south crater into a raised plateau may be attributed to the materials ejected from the north crater. On this crater-plane fresh eruptions took place at Mt. Saraceno, at the junction of the two ancient explosion crater rings. From this cone part of the lavas poured down on the great crater-plane, Il Piano. Other outpours of basalts, with the formation of the cones of La Sommata, all helped to raise the floor of the great explosion-crater of the south half of the island to a plane. From the bottom of the crater of explosion in the trachyte cone, a new and at present active cone grew up, the later products of which are acid rocks, chiefly varieties of obsidian and its allies. In historic times, some distance to the north of the island, in the straits separating it from Lipari, eruptions of dolerite lava, scoria, lapillo, and dust took place, forming the present triple-cratered cone of Vulcanello with its surrounding platform of lava.

After a rough scramble the party descended to the Porto di Levante, embarked on the steamer, and steered for Messina, in the port of which town we passed the night.

Early the next morning, September 24th, we steamed out of the Messina harbour, and, after quitting the whirlpools, were much troubled by an increasingly rough sea, so that our hope of reaching Acireale and landing there was given up before we reached Taormina. The effect of sea-sickness on the majority resulted in the captain being ordered to land us at the first sheltered point. The operation of disembarkation, the finding of an ox-cart, and the transport of our luggage over part beach and part road to the Giardini Station, and our collapsed selves, must have presented a serious-comic side to the few observers of this group of disciples of Vulcan retreating from the domination of Neptune. That evening we arrived in Acireale and found ourselves once more amidst comparatively civilized life. There we were met by Prof. O. Silvestri, of Catania, and his son, who seems

to be a worthy pupil of his father. Here I handed over the reins of direction to Prof. Silvestri, satisfied that they were in more competent hands, the more so that I was really very ill. Messrs. Gaetano and Giovanni Platania—the former a Member of our Association, and an old travelling companion of mine in the Aeolian Islands, who had been of so much assistance in directing the party there, not only still continued to do so here, but in their native place of Acireale—rendered us most valuable services.

The following day we took carriages to Zafferana, and then, some on foot, others on mules, we ascended into the Val di Bove, Prof. Silvestri lucidly indicating and describing the important geological points along the way, such as the lava cascades of Val Calanna, the configuration and limits of the Val di Bove, the parasitic cones and lavas occupying its floor. Beneath the escarpment under Mt. Pomiciaro we were able to examine some of the radial dykes, the lava streams, and numerous other points of lithological interest. This was followed by an "al fresco" lunch, which unfortunately was cut short by a storm. A number of us pushed through the driving rain to near Lyell's axis of Trifoglietto, from which point the sight is imposing, especially with the addition of the drifting clouds.

The same evening the excursionists had been offered a banquet by the municipality of Acireale, and on their return from the Val di Bove were pleasantly astonished on their entry to the town to find it artistically illuminated in their honour. After dinner, during which the very fine town band had played a series of pieces, toasts were drunk by some of our members, and replied to by the Sub-Prefect, the Syndic, and Messrs. Platania. This small, but pretty and clean town owes much to the late well-known Baron Panisi, who founded here a meteorological and seismological station, and in many other ways has been active in making Acireale, with its grand hotels and thermomineral establishment, what it now is, a place from which many continental Italian cities might take an example.

On Thursday, September 26th, under the direction of Messrs. Platania, on the path down to the beach, the different superposed doleritic lavas of Etna were examined, and after refreshment at one of the directors' houses, we embarked on boats, which first conducted us to the remains of the Grotto delle Palumbe, where a thick stream of dolerite exhibits, for such a coarse-grained rock, very fine columnar structure. The

energetic rowing of the fishermen took us rapidly along the coast, where very ancient Etnian basalts are intricately interwoven with Pliocene clays; where lava-stream succeeds lava-stream; where the fig-cactus and the vine monopolize every metre of loose scoria or lapillo; and where at some points fine ferruginous springs gush out from the cliff-face.

On our landing at Trecza, the largest of the Cyclopean islands, Prof. Silvestri pointed out that it was in part composed of clay metamorphosed by the contact of the basalt forming the other part of the island. The members were able to observe numerous minute dykes extending into the clay from the main mass, and to collect some very creditable crystals of analcime from the basalt. This mineral has been subsequently introduced into the basalt in such great quantities as in some cases to convert it into a rock which has been called analcomite. Landing at Aci Castello, the celebrated globular basalts, with their associated palagonite tuffs, containing hercynite, phillipsite, and other zeolites in abundance, furnished ample scope for observation and discussion by the party. A comparatively recent but non-historic lava-stream is seen at one point covering some of these more ancient Etnian productions. Before taking the train to Catania, a fine fan-shaped group of basalt columns was examined close to the station.

On Friday, September 27th, invited and conducted by Prof. Silvestri, the fine museum of the University was visited by the party. This collection, probably the finest vulcanological collection that exists, and especially the beautiful models of recent eruptions of Etna, and the collection of their ejecta, were much admired. Not less valuable are the fine series of rough rock-specimens, with their polished equivalents and large very thin sections from the same. The Sicilian sulphurs, ambers, and other minerals add to the beauty of the collection. The museum also contains a fine series of seismological instruments. The whole represents many years of toil on the part of Prof. Silvestri.

In the afternoon we drove to Biancavilla, noticing the numerous large lava-streams cut by the road, chiefly outflows of 1669. At Paterno, the so-called mud-volcanoes, or "Salse," were examined, which, although now comparatively inactive, in 1879 showed great activity. Here Prof. Silvestri gave a discourse on the phenomena of mud-volcanoes in general,

which he illustrated by those in the midst of which we were standing. He then conducted us to the neighbouring Acqua Grassa, which is seen to be two rectangular basins, containing about two cubic metres each of a ferruginous water in a constant state of ebullition from the escape of carbon-dioxide, constituting a splendid drinking water, of which most of us availed ourselves with gusto.

It was nearly dark when we arrived at Biancavilla, having made another stop to collect specimens of the augite-andesite at the foot of the cone of Mt. Calvario. At Biancavilla we had been kindly offered hospitality in the country-house of the Marquis di Favara, a most valuable help to us, for which the party were most grateful, as there is nothing approaching an hotel in the place. Soon after our arrival the Syndic, some of the municipal councillors, and the town band came to greet us, the latter playing to us whilst dining.

At daybreak the following morning we were up, and the large quadrangular court-yard presented a picturesque scene—with over twenty mules, many recalcitrant, lethargic muleteers, excited geologists, odd-looking baggage, with the writer running here and there, directing, scolding, hurrying, urging, and otherwise stimulating the guides and mule-drivers.

Notwithstanding that the starting had been ordered for five a.m., it was nearly six before we were all fairly on our journey. A splendid morning, Etna, standing out in all its grandeur, was a picture that few who saw it will not have indelibly engraved on their memory. Not less impressive were the numerous wild, rugged lava-streams that were crossed, alternating with vines and woodland, with here and there a gigantic parasitic cone. Thus we continued till near midday, when we halted at the cones of Grotta degli Archi to eat our well-earned lunch, which was followed by a demonstration from Prof. Silvestri of the way in which these cones were formed along a lateral fissure, now known as the Grotta degli Archi, or Grotto of Arches, a tunnel the upper portion of which we entered, representing the upper extremity of the now empty dyke, and forming an arched communication from one parasitic crater to the other.

Another few hours of climbing on our mules brought us past the eruptive fissure of 1879 to the edge of the Piano del Lago, beyond which all is desert. At about 5 p.m. we reached the

Observatory, and, depositing our mules and baggage, I called upon those near by to follow me if they wished to see the crater that evening, as we did not know what weather we should have on the morrow. Six or seven besides myself started, and although I did not know the new path since the last eruption, fortune favoured us, and in spite of a strong and biting wind we were able to obtain a fine view of the crater and circle round more than half its circumference, which is probably more than a mile. It is now in a solfataric state, with nearly perpendicular walls and flat floor, probably some 100 to 200 metres beneath the rim. We descended opposite the Observatory, and had an amusing scramble over a very steep slope of hot, fuming, compacted dust.

Unfortunately, after a terrible night of piercing wind and driving cloud, the following morning rendered the ascent that was to be made under Prof. Silvestri's direction impossible, and some of the party had to descend disappointed. It is not the crater of Etna, however, that is the great centre of interest, but the innumerable things that one observes in the ascent and descent. After leaving the Piano del Lago on our way down, we quitted the clouds which were simply capping the mountain, and on our path to the Casa del Bosco, where we lunched, we often had bright sunshine. At the Observatory, thanks to the kindness of Prof. Silvestri, we had been most hospitably fed, and even at this point we had again to fall back on the abundant supply of provisions that he had provided for us.

Our next goal was the eruptive focus of 1886. We struck out of the main path for Mt. Gemellaro, a very large parasitic cone thrown up during that outburst. A considerable number of the bombs, containing partially fused quartz, thrown out on the flanks of the cone, were collected, and after photographing some peculiar lava formations, we continued our way down amidst a slight rain which rapidly increased, so that we had to hurry past the foot of Mte. Rossi without stopping to examine it. At Nicolosi we were met by carriages which conveyed us to Catania. The next day we took train to Messina, crossed to Reggio, and then went for twenty-four hours by train to Naples. The latter part of the journey, though undoubtedly fatiguing, was of great interest on account of the physiognomy of the country, from which many interesting lessons of

mountain and valley formation as well as of simple denudation could be learned.

On October 1st, the second group of the party, who had assembled in Naples, visited the National Museum, the churches of S. Chiara, Duomo, etc., Dr. A. Sambon, who especially occupies himself with mediæval art, acting as director, and in the evening they were joined at Parker's Hotel by the section from Sicily.

The following morning (Tuesday) a couple of hours were passed in examining the Zoological Station, its well-fitted laboratories and scientifically and artistically arranged aquaria, under the able guidance of the vice-director, Dr. Eisig, and MM. Linden and Megazini. We then proceeded in carriages to Camaldoli, where a magnificent view of the Campi Phlegræi is obtained. After lunch, the writer said he had brought them there to point out the general configuration of the country to be visited during the next fortnight. On the one hand was the Gulf of Naples, with its south-west side bounded by the Cretaceous and Jurassic Limestones of Capri and the Sorrentine peninsula, while at its deepest concavity rose in elegant, sweeping curves, broken by jagged precipices, the pile of Somma and Vesuvius. Then came the true Phlegraean Fields, including the amphitheatre of Naples, the ridge and Cape of Posillipo, Nisida, the hills of Mte. Dolce and Mte. Olibano, La Starza with Pozzuoli, Mte. Nuovo, the Luerine lake, Baths of Nero, Baiæ, Bacoli, Mare Morte and Misenum on the mainland, but also the geological prolongations of the Islands of Procida, Vivara, and Ischia. The latter islands formed the south boundary of the Gulf of Gaëta, with Monte di Procida, Fusaro, Cuma, and then that long sweep of low ground of Castel Volturno, Mondragone broken only by the limestone bosses of Mte. Massico, until close to Gaëta, which is backed by the calcareous pile forming the north boundary of the gulf. The numerous cones and craters at our feet in all stages of ruin: the plains of Bagnoli, Soccava, Pianura, Quarto, in part due to old craters of explosion; later submarine bottoms when the waves lapped the foot of Mte. Barbaro and the base of the precipices we were then looking down from; the bright sun, the blue sea, and green foliage after the first autumn rains, combined, with the fantastic configuration of the country and its varicoloured rocks, to form a picture unique in itself and of

uncommon beauty. In fact, all the party admitted that they could hardly decide which impressed them most: the valuable geological lessons to be learnt from the district, or the beautiful outline and colouring of the landscape. Regaining our carriages we directed our course to the new quarter of Naples, now being constructed on the Vomero hill, where some good sections are exposed. The great mass of almost uniform yellow tuff cut into for some 25 metres is well seen overlaid by numerous comparatively recent, though pre-historic, trachytic pumice and dust beds, on which the writer expressed the opinion that they were derived from the craters of Astroni, Fondo di Ciglio, and the Fossa Lupara. He also pointed out nuclei of greener tuff passing into the characteristic yellow variety towards the surfaces of cracks and fissures, due to higher oxidation. The museum of San Martino was closed, but by the kindness of the Conservator, by order of the Minister of Public Instruction, a short round was permitted. From two of the balconies the topographical features of Naples, Somma-Vesuvius, and the Sorrentine peninsula were explained more fully than at Camaldoli.

That evening it had been intended that I should give a lecture on the geology of the Neapolitan district, and I had commenced to carry that determination into effect, but was prevented from continuing by an increase of ill-health that I had been battling with for a fortnight, and the following day I was compelled to remain in my bed. Fortunately, Prof. Bassani kindly replaced me, and under his care the party were conducted to the celebrated Grotta del Cane and the neighbouring thermo-mineral springs of the Lago d'Agnano, with the fumeroles of the Stufe di San Germano. From thence they proceeded to the Solfatara, where Prof. Bassani explained the phenomena of this semi-extinct volcano, how its emanations attack the trachytic tuffs, decomposing them into kaolin, free silica, alumina, and sulphates of the bases, which the party collected in the form of halotrichite, coquimbite, voltaïte, copiapite, gypsum, etc. Lastly, the party examined the renowned so-called Temple of Serapis, where the phenomena of oscillation of the land-level are fully demonstrated.

Sufficiently recovered from my indisposition, it again fell to my lot to grasp the guiding reins, so that on October 4th (Friday) the Campi Phlegrei was our goal.

Approaching Monte Barbaro from Pozzuoli, I drew the attention of the party to the irregular and ruined appearance of the south side of the mountain which extended round and had made so much progress as to leave a breach in the east side of the great crater, so separating, on this side, Monte Corvara, which constitutes the north side of the cone, and the crater of Campiglione, from Monte Barbaro which forms the south side. Towards the west the crater is also in part breached beneath S. Angelo, but not to such an extent; yet it is sufficient to mark the separation of Monte Corvara and of Monte Barbaro on the opposite side of the crater. It was by this former breach that we obtained admission to the great crater of Campiglione, the plain at the bottom of which is now covered by fields and gardens. This erosion of the front and sides of Monte Barbaro took place when the land-level was very much lower, so that the waves had in part destroyed this, the largest cone of the Campi Phlegrei. The deposits at the sea-bottom constitute the materials now forming the plains through which have risen, at a later date, the volcanoes visible from a point we had gained on the south-east limb of Mte. Corvara, namely: Astroni, Cigliano, Senga di Campania, Mte. Olibano, Solfatara, Mte. Nuovo, etc.

The old coast-line at the epoch when the waves lapped the base of Mte. Barbaro, and when the sea-level was some 60m. higher than at present, was as follows: Starting from the Island of Nisida it swept round the toe of the Posillipo ridge to Fuorigrotta, cutting back the cliffs behind Soccava, and beneath Camaldoli, thence to Pianura, and by a less distinct coast-line until we again meet a well-marked cliff which some distance to the west is traversed by a cutting for the road to Qualiano. The coast-line makes a sweeping loop to the south round three quarters of the Campiglione volcano, and probably including the upper rim of the Avernus and Lacrine Lakes. Monte di Procida, and a few other points of the Baja peninsula, were then islands, as well as such rocks as that on which Pozzuoli was built, Mte. Dolce, near Bagnoli, and probably Mte. Spina and some old trachyte and tuff bosses in part sheared by the eruption of Astroni on its east side. These latter eminences seem to have acted as breakwaters, and in consequence we find the old coast-line behind them more prominent and possessed of less abrupt declivities; that is that portion

from Pianura westward to a point just north of Segna di Campania.

After having examined the conformation of the Campiglione crater, we returned to the exit, near which was a quarry of the yellow tuff which composes the main mass of the cone. Numerous large fragments of grey pumice stone, quite fresh in the interior, but decomposed on the surface to a kind of palagonitic matter, illustrated how the whole of the smaller pieces and dust had undergone a similar change, blending the heap of incoherent fragments into one compact mass. This enormous collection of pumice indicated a gigantic explosive eruption which had not only built up the present cone, but probably had afforded much of the compact yellow tuff of the region, the position of which would indicate that the Campiglione volcano was later than the centre or centres from which was derived the grey piperno tuff of the Campanias, the piperno and the museum breecia of Pianura, Soceava and Naples.

The party then proceeded to Mte. Nuovo and ascended to the summit of the mountain, which was built up in the course of some forty hours by the constant ejection of pumice and other materials from an eruptive axis passing through the streets of Tripertola, a village with thermomineral baths on the seashore. The geologists might perceive that the main mass of the mountain was composed of a trachytic pumice, over which was spread a mantle of great masses of a dark, very basic trachyte (sometimes considered a phonolite), occasionally compact, but more often scoriaeous. This, I said, I considered to prove that while the magma in the upper part of the chimney was saturated with dissolved water, that lower down, and farther from aquiferous rocks, was less so, and had the eruption become permanent, no doubt lava would have poured out continuously. Many of those present collected fossiliferous concretions, which are similar to those found in the submarine marly tuff of Ischia, and in the submarine tuffs of the Starza which underlie Mte. Nuovo, and which are the deposits of the epoch of the erosion of Mte. Barbaro. Descending to some pozzuolana quarries, I pointed out that when we cut into the mountain for a few yards, we could see that the pumice and pozzuolana had already been converted into a yellow tuff much like that of Mte. Barbaro, although only 250 years had passed since its ejection as new material.

The crater lake of Avernus and the Lærine lake were next visited, and the return journey included an examination of the Starza cliff, where a large collection of fossils was bagged. The following explanation was given : The materials here seen in section were derived from different sources, and in part by marine erosion of Mte. Barbaro, and were deposited at the sea-bottom when that erosion was progressing as described above. Immediately previous to the historic period, and after the rising of the land some 60m., a marine terrace was cut in these deposits with a cliff face from 10 to 100m. nearer the beach than at present. The Romans built along near the edge of this cliff, and on the foreshore at its foot (Temples of Serapis, Nymphs, and Neptune), and during this period depression was going on, the temples of the Nymphs and Neptune were probably abandoned, and a new and higher floor was added to that of Serapis. Up to the middle ages this depression continued, until the sea once more had covered the foreshore and cut back the Starza cliff to its present position, exposing and undermining the foundations of the Roman villas above. Part of these fell, were broken and rounded by the sea, and converted into pebbles. The exposed beach, with black sand, shells and brick and marble pebbles, was shown to the party, opposite the main gate to the Armstrong Works, at a height of 3·75m. above present mean sea-level.

In the evening the party paid a visit to my house to examine my private collection of rocks and minerals from the South Italian volcanoes, the former being by far the most extensive and choice either public or private, and the latter the finest private collection, or second only to that at the University, and therefore likely to prove of considerable interest to geologists visiting the neighbourhood.

The following day (Saturday, October 5) the party proceeded in carriages to the Vesuvian Observatory, and thence on foot to the Atrio. During the ascent the lavas of 1631, 1767, 1858, and 1872 were examined. The scoriaceous lava surface, with its bombs and the pahoehoe or corded type, with but few bombs, were pointed out, and explanations of the reasons of this were given. In the Atrio the dykes, lava-streams, and conglomerates were examined, and the condensation and agglomeration of the latter into a solid rock towards the lower part and centre of the great escarpment were shown to result

from heat and pressure. The newly-discovered hollow dykes and those that had been drained out and refilled a second, and even a third time, excited much interest.

The barren, rugged, and jagged lava-fields of the Atrio, the stupendous precipice, the frowning cone of Vesuvius, with its jets of stones and volumes of vapour, the latter mingling with the storm-clouds scudding through the ravines and around the towering peaks, strongly impressed those present with their grandeur.

With a basket or two of lapillo, a model was improvised to illustrate the causes of the configuration of this volcano at different periods of its growth. Some of the party descended by the Cupa Pallarino (once called the Riva di Quaglia), where the pumice beds of Somma are well seen, and where a good selection of the various ejected blocks can be collected.

The Sunday (October 6th) was occupied amongst the beauties of the National Museum, Dr. A. Sambon's demonstrations being very interesting and valuable.

Attention was drawn by myself to the various stones used in the arts there represented, as well as to the different minerals formed by the decomposition of the bronze antiquities. In the afternoon about half the members accompanied me to the tunnel of the Mte. Santo-Vomero funicular Railway in Naples, where the newly-discovered sections of interest are to be seen. A rich collection was made of rocks from the "museum" breccia as well as of the grey pipernoïd tuff. The details of this section have been described in the 'British Association Reports' (Vesuvian Committee) during the last three years. In the evening, boxes at the Bellini Theatre had been offered the party by the municipality of Naples, and a pleasant distraction from vulcanological work was found by the excursionists in Gluck's charming opera of "Orfeo."

On Monday (October 7th) the triple crater ring of the Fossa Lupara or Senga di Campana was visited, but the height and denseness of the vegetation prevented a good general view being obtained. Subsequently the sections of Pianura and Soceavo were examined. The problem of the "piperno" was broached by me somewhat in these words. Those of the party who had seen the tunnel section on the previous day would recognize its similarity to that before us. The massive yellow tuff, beneath which comes, in both cases, the "museum"

breccia, reposes, in its turn, at Naples on pipernoid tuff, and at Pianura on piperno, and these respective materials on white pumice beds. This showed that the grey pipernoid tuff and the piperno were stratigraphical equivalents. The former had all the characters of a tuff, the latter those of a lava, as indicated by flow-structure around the numerous fragments of greenish-yellow tuff, etc., caught up, by the overlying fragments of a more vitreous variety of the same, and by the presence of two (especially at Soccavo) distinct flows separated by a breccia of trachytic rock-fragments. Some authorities had supposed the piperno to be a metamorphosed tuff, but an examination of the section disproved that view, since the underlying pumice was unaltered, as also the trachytic breccia between the two flows of piperno. These facts lead us to the conclusion that not far from here, and probably a little to the south of Soccavo, at one time stood the great piperno volcano, subsequently destroyed by explosive eruptions and marine erosion, and that this was the centre from which was dispersed the grey tuff of Naples and of the whole Campania, which is of the same age. As regards the origin of the pipernoid structure, it could be explained by supposing the vent opening at the top of a fissure filled by the original magma, at the junction of two portions which contained different proportions of dissolved water and had undergone different stages of crystallization from cooling. The pasty magma would then issue with a laminated structure, just as different coloured clays or soaps do through a narrow aperture, the greater cohesion of the black, more vitreous, and less cooled portion causing the separation of the laminae into larger pieces, which, with their peculiar, crushed, and squeezed-out surface, have remained in the lighter coloured, more granular, crystalline, less cohesive, and cooler ground-mass, which from containing more water tended to its disintegration to dust.

On Tuesday (October 8th) the train was taken to Pompeii, where Dr. A. Sambon acted as archaeological director, and the beauty of the buried city being duly admired, the attention of the party was turned to the materials in which the town was buried. The pumice, with the more vitreous lower part, contains, as porphyritic inclusions, crystals, chiefly of intratelluric minerals; whilst the upper part, darker in colour and more microcrystalline, has inclusions of crystals of post-eruptive

minerals, and above these pumicees come the pisolitic dust-beds. These are followed by very thin lapilli beds of later eruptions. The lenitic lavas on which the town stands, and the different rocks used in the arts by the ancient inhabitants, also attracted attention.

Signor Dini had kindly placed his steam-tug at the disposal of the party to visit the quarries of 1631 lava owned by him, which are the largest and best worked on the mountain. The rough sea and unfavourable weather prevented our availing ourselves of that kindness, and also of refreshments it had been the intention of the proprietor to offer us. After visiting Pompeii, we drove over to one of the smaller quarries of the 1631 lava, where the irregular columnar structure, shearing-planes, steam-eaverns, and seoriaeous surfaces with bombs, could be well seen in section.

Early the next morning, being joined by Professor Bassani, we drove to the quarries of Faiano, near Noeera, where the grey pipernoid tuff is seen and quarried to 20 metres in depth. I explained that these tuffs are found all over the Campanian plain and a great part of the Terra di Lavora, almost uniform in structure. Where they are in close vicinity to high limestone mountains they contain fragments of that rock, which are more or less, according to size, converted into silicates and fluorides, which was supposed to be due to the action of hydro-fluosalic acid, which probably formed one of the soluble constituents of the dust as it fell. What was of great interest was the fine crystals of biotite and nepheline, besides pyroxene and amphibole. Of not less important bearing on the temperature and pressure of metamorphism was a deer bone, which I lately found there, covered with amphibole and some nepheline crystals, but still retaining traces of animal matter. The age of this grey tuff is indicated by its stratigraphical position, which, taking distance into consideration, is similar to that of the grey pipernoid tuff of Naples and the piperno of Pianura. At Fiano and the neighbouring Fossa Lupara (not that north of Astroni) the grey tuff is overlaid by the Somma pumicees representing the eruptions that excavated the Atrio del Cavallo crater (PHASE III to VIII). In the great Atrio section, we have exposed the different mantles of volcanic ejectamenta, the lowest of which date back to the time when the entire cone of Somma could not have been as high as the present Vesuvius;

yet no traces of it are to be found, so that it must be more ancient.

Rejoining our carriages, we drove along the Sarno plain, at the foot of the limestone mountains to Castellamare, Professor Bassani pointing out the characters of the sedimentary rocks. After dinner, Professor Bassani gave a very able and interesting discourse on the orography of the Sorrentine peninsula and Capri, together with an account of the recent geological investigations of that district.

On the following morning (Thursday, October 10th), under the joint direction of Professor Bassani and myself, the sections exposed along the road from Castellamare to Sorrento were examined. We descended from the carriages at different points to visit the fine exposures of the Neocomian ichthylitic limestones and the Orbitolina-marls (Aptien), ably guided by Professor Bassani.

Just before Vico Equense, we descended to the bathing establishment, where nearly at sea-level a very abundant spring of a very rich sulphur water issues, and the products of oxidation of its sulphur-compounds erode the limestone into fantastic caves, from the fissures of which abundant crusts and crystals of selenite, as well as some epsomite, can be collected. Close at hand I drew attention to a patch of the grey piperoid tuff, with pieces of limestone partly converted into fluorides, etc. This tuff is seen reposing on some much older volcanic deposits, yellow earth and pumice collected in depressions in the limestone.

On our arrival at that point of the road which overlies the plain of Sorrento, I explained the structure as follows: the Sorrento peninsula represents an upthrow along a line of fault marked by its southern coast. Springing from this main fault, nearly at right angles, extend a number of transverse ones, and between two of these a depression is formed by a downthrow. This lower slope has been partly levelled by filling up with grey piperoid tuff similar to that we saw at Nocera and Naples. This tuff is beautifully seen from our standpoint, forming a long line of cliff limiting the plateau seawards. These cliffs have a coarse columnar structure, which in other localities is often developed to great perfection, and the tuff near the contact with the limestone contains the usual inclusions.

The municipality of Naples had kindly placed a large steam-yacht, the "Sibilla," at our disposal, and on our arrival at Sorrento we were met by a deputation of representatives from the Naples municipality, consisting of Professors Majone and Roccatagliata, and Captain Vercilli, with whom we immediately embarked.

Within an hour we found ourselves at the Blue Grotto of Capri, which we were able to visit, owing to the calm sea.

On landing, our party, which was now over fifty in number, were divided amongst three hotels. After lunch, the prehistoric flint and obsidian implements, rocks, minerals, etc., of the island, carefully collected by Dr. Cerio, were exhibited by that gentleman, and the thanks of the party were offered to him with the expression of their admiration of his efforts to get together under many difficulties this valuable local collection. Later the party ascended to the Palace of Tiberius, and along the road Professor Bassani lucidly explained his own views, as well as those of Oppenheim and others, on the relationship of the Jurassic and Cretaceous rocks of Capri to those of the Sorrentine peninsula, and other parts of the mainland. From the ruins of the Palace of Tiberius the magnificent view at sundown, and the historic reminiscences called up by the locality, and ably recorded by the Rev. J. C. Fletcher, of Naples, deeply impressed everyone. After dinner, the party accepted coffee, etc., offered by the Mayor of Capri, and walked over to the Villa Tragara, the property of C. W. L. Ostermoor, Esq., of London, from which a magnificent moonlight view of the island was obtained, and where a pleasant hour was spent in admiring the scene, and consuming the liberal supply of refreshments provided by Mr. Ostermoor.

The next morning, October 11th, found us betimes on board the yacht, and a pleasant steam of two hours brought us to Casamicciola in the Island of Ischia. I had requested the captain to take the course outside Procida, so that those on board might admire the remarkably picturesque situation and surroundings of the town of Procida, and look into the partially submarine crater of Vivara Island. On landing at Casamicciola, the town authorities met us, and placed carriages at our disposal, with which we proceeded to visit some parts of the island. Monte Rotaro crater with the Monte Tabor lava-stream of mellilite trachyte, the craters of Montagnone, Porto d'Ischia,

the trachyte dome of Castello d'Ischia, and the bosses of ancient trachyte were pointed out. The road we followed lay for some distance over the olivine-trachyte lava-stream, the rough surface of which is still well seen, although at many parts small pine copses have been planted. Passing close to the irregular crater ring of Cremate, I pointed this out as the source from which this lava-stream, called the Arso, flowed in A.D. 1302 for a distance of two miles, when it entered the sea, forming a promontory. The Molara and another parasitic cone and crater were examined. At Testaccio, quitting our carriages, we descended to the beach of Maronti, but owing to the heat and the tiring walk on sand, the party did not reach the place where the beach and sea-bottom attains a temperature of boiling water; nevertheless, some fine gorges in alluvial tuff, illustrating denudation, the formation of earth-pillars, etc., were examined. On the return of the party to Casamicciola, the remaining half-hour at our disposal was devoted to a drive round the earthquake ruins of the town. After a sumptuous dinner, at which over 50 people sat down, votes of thanks were offered to the municipalities of Naples, Capri, and Casamicciola, and their representatives. So high did the spirits of the company rise, that even ladies became eloquent and proposed toasts, which, though short, were no mean specimens of oratory.

A calm sea, a bright moon, and a soft evening, made our return trip to Naples such as is not to be forgotten. The deep indigo sea, and the trace of haze gave to the promontories, islands, and rocks a fantastic beauty, whilst the majestic, sweeping curves of Vesuvius, crowned by the jewel-like volcanic fires and vapour plume, reminded us that amidst all this beauty beneath and around us, the great igneous forces of nature were but in a recuperative slumber, a slumber the awakening from which will be earthquakes and eruptions.

The crater of Vesuvius, the principal focus of the volcanic activity of the Naples district, was the centre of the hopes and wishes of the party. I had placed it at the beginning of the programme, but for ten whole days either strong wind or cloud cap had prevented me from making the excursion. Over sixty visits to the Vesuvian crater had taught me to be cautious, but some members of the party, inexperienced of the locality and impatient to get there, openly rebelled and went on their own

account, of course failing to see anything more than mist. Saturday morning, 12th October, being more favourable, I gave the order for Vesuvius. Fortune favoured us in every way, and even a little cloud that had collected on the mountain top dispersed before our arrival. Four concentric crater-rings were visible, and at the bottom of the central one, two vents which all the party were able to approach within twenty yards, were giving issue to high-pressure vapour and pasty lava-fragments. Descending some 100 metres on the east side of the great cone, we were able to approach a small stream of lava, upon which various experiments were performed.

Sunday, October 13th, was a well-earned day of rest, and, although, owing to the loss of two days, the excursion to Monte Somma should have been undertaken, yet the majority of the party prayed for rest, and none desired it more than myself, still imperfectly recovered from my indisposition.

One or two of the youngest members of the party, however, had a successful trip to the locality. Neither on Monday could all the attractions of the Mineralogical Museum of the University, or the extensive knowledge of its contents of the venerable Professor, A. Scacchi, infuse sufficient stimulus in the flagging energy of the party. Packing the numerous spoils of the vulcanological chase required a considerable share of the morning.

Starting by the 3.25 express train, we arrived at Sparanise just before sundown, and were met by carriages placed at our disposal by the Province of Terra di Lavoro, to convey us to the town of Sessa Aurunca, where we arrived some time after dark. As the town possesses no hotel, the municipality had kindly allowed us to sleep in the Lyceum, the scholars being sent to their homes or friends' houses. The married couples were placed in different private houses. In the hall dedicated to the celebrated Nifo, a native of Sessa, a luxurious banquet was offered us by the town, most of the municipal authorities being present at the table.

The following morning (Tuesday, October 15th), after coffee offered by the municipality, we mounted in carriages, again provided by the province, personally represented by Prof. Spatuzzi. It was fortunately market day, and what the ordinary visitor, who follows the regular travellers' track, does not see, was a most interesting spectacle to our party. As we

wended our way up the vine and olive-clad slopes of the extinct volcanic pile of Roccamonfina, the yellow tuffs, then the leucotephrite and leucitite lavas and breccia beds, were of great interest. The peculiar decomposition of the former rock into a kind of concentric lamellar wacke, which often completely involved a stream, and made it look like a tuff, taught an important lesson to those who had studied ancient volcanic rocks. Near the entrance to the great crater-ring the explosive pumices and lapilli, near a great leucitite dyke composed of large leucite crystals in a fine-grained base, are well seen in the road-section. A little beyond, overlying all other deposits, we have the grey piperoid tuff in columns that we had studied at Naples, Faiano, Vico and Sorrento. The town of Roccamonfina is the birth-place of the Com. N. Amore, the Mayor of Naples, who had done so much for us during our stay there, and he had determined that we should be equally well received in the town of his boyhood. On nearing Roccamonfina, we were met by the Mayor, Town Council, and the other notabilities of the place, including Com. Amore's brother. We had to descend from our carriages and enter the town in state procession, preceded by a town band, and amidst the shouts of welcome from all the inhabitants, who had turned out to see "gli scienziati Inglesi."

While lunch was being prepared, we ascended to the Pietritroccoli, one of the central eminences of the mountain. From this favourable position I made the following observations:—"You will notice the striking similarity in size and configuration of this volcano to that of Somma-Vesuvius. This similarity even extends to the leucitic rocks forming the main mass of the mountain. Some years since I spent some weeks in studying this volcano, but have never published the observations then made. Doctor Bucca and Signor P. Moderni, both of the Italian Geological Survey, have since then published short memoirs on the mountain. The researches of the former are chiefly petrographical, and his views quite correspond with my own; and Signor Moderni has added much to our knowledge of the sequence of the different eruptive products, especially the lavas, and I propose to supplement those researches by alluding to the information to be derived from my own observations.

"So far as we know, the volcano originally consisted of a gigantic cone, built up by the constant outpouring of lavas and

the ejection of scoria, lapillo, and dust. These materials were both characterized by the presence of leucite, and, according to the researches of Bucca and Moderni, the earlier outpours are of leucitite and the second of leucotephrite. My own observations lead me rather to consider them as intermitting with one another, and also to conclude that during the leucitite phase explosive eruptions occurred with the production of much white and grey pumice, pumiceous scoria, etc. As the great mountain grew, parasitic cones burst forth from its flanks, from which flowed the leucitic lavas, and Signor Moderni enumerates no less than a dozen such, still recognizable. The main volcanic cone having attained an altitude of from 2,000 to 2,500 m., one or more violent explosive eruptions truncated this cone down to less than 1,000 m. in height, leaving a large crater-cavity from five to seven kilometres in diameter. This or these explosive eruptions were around an axis a short distance to the east of the old one, upon which had been built up the old cone during long periods of Vesuvian activity. The products of this or these explosive eruptions we see in the numerous and extensive beds of white pumice and yellow tuff derived therefrom on some of the upper parts of the mountain, and especially around its toe. Around this new axis of eruption, exudation rather than eruption of an augite-andesite lava took place, building up a great triple dome or mammelon, on a portion of which we are now standing, and partly filling up the great crater-cavity. The annular fossa between this central cone was subsequently filled up level with the lower part of the great crater rim by fragmentary eruptive materials from other centres, and by erosion of the central cone and the inner crater walls. The latter are known at present as Monte La Frascara and Serra Piccola, or sometimes as Monte Cortinelli. You will recognize the analogy of this crescentic enceinte with the similar escarpment of Monte Somma, the circular plain on which the town of Roccamonfina is situated, with that of the Atrio del Cavallo and the Pedimentina, and, lastly, the compound cone of Monte S. Croce, Lattani, and Pietri-troccoli, on which we now stand, with the great cone of Vesuvius. Trachytes were poured out from thirteen lateral cones at an uncertain date, which Signor Moderni places just previous to, during, or after the production of the great central andesite mass. Then followed a period during which nine other parasitic cones gave forth basaltic:

lavas, scoria, etc. Two of these latter had formed on the crater plain, constituting the hills of Tori Sichi and Garofali.

"At a still later date enormous quantities of a fine dust were deposited on the volcano from some distant source, which, when washed down, choked the valley by the resulting tuff, which often exhibits beautiful columnar structure, and if not identical with, bears a very close relationship to, the grey pipernoid tuff of the Campania."

Descending to the Town Hall, we found a plentiful lunch awaiting us, provided at the expense of the Commune, to which we did full justice after our long walk and climb. After taking coffee at the house of Cav. Amore, we again resumed our carriages, and drove down to Mignano. Although rain was now falling, we stopped at various points along the road, and at one spot made a good bag of large leucite crystals. At Mignano station we took the Roman express, it having been stopped for us by order of the Minister of Post and Telegraphs. We descended at the station of Cassino, and had over an hour's drive in torrents of rain to the top of Monte Cassino, where we were most cordially received by the prior, Dom Oderisio Piscicelli. One carriage had broken down on the way, and the occupants had had to tramp the rest on foot, one gentleman being only shod in thin slippers. A luxurious dinner, served in the great hall of the monastery, soon restored our drooping spirits and exhausted energies, and after a pleasant chat with the prior and other monks we retired to our comfortable cells, and slept a blessed, and, I hope, a saintly, though certainly profound sleep. The ladies had been quartered at the Foresteria, outside the monastery, and were equally well treated.

The next morning they were allowed to join us, and visit this remarkable centre of culture, with its valuable works of art, archives, antiquities, natural-history specimens, etc. The reproduction in lithography of the designs of ancient ecclesiastical robes and the printing and publishing of the contents of the innumerable manuscripts were all duly appreciated.

Lunch was served in another apartment, where ladies could be admitted, and the honours of the table were taken by the Rev. Prof. Laitine, a French monk specially delegated to receive strangers. After expressing our gratitude to the prior

and all the fathers of Monte Cassino, we commenced our descent on foot. Prof. Bassani, of Naples, who was to have directed, being unable to be present, had kindly handed me the following notes, which I communicated to the members :—

Monte Cassino is entirely composed of Cretaceous rocks containing *Hippurites*. The rock is a compact limestone, sometimes arenaceous, of a dirty white, dark yellow, or carnation colour. It is always traversed by veins of crystalline calcite, and often resembles that of Castellamare. The stratification is rarely clearly defined, but may be well seen at the commencement of the road from the town to the monastery. Three quarries occur in the neighbourhood, one just north and to the right of the station; another north of the town, and at the base of Monte Silvestro, beneath and to the north of Castello Manfredo (Rocca Jovina). The strata dip in the former 30° towards north, 40° west; and in the second, 42° towards north, 40° west. The third quarry is the most interesting, because one can easily collect specimens of *Hippurites* from it. It also exhibits a calcareous breccia. It is situated a few paces from the carriage road to the monastery, about twenty minutes' walk up.

A considerable number of specimens were collected, amongst which were some crystals of sulphur, which I discovered in a geode, its first known occurrence, I believe, in these Cretaceous rocks. Again joining the express train to Rome, we arrived at that city late in the evening, and took up our quarters in the Via Sistina, in the pension of Mrs. Dawes.

The following day (Saturday, October 19th) being wet, we visited the Museum of Geology and Mineralogy of the University, under the valuable guidance of Professors Strüver, Portis, Clerici, Tellini, Bucca, etc. The interesting series of minerals from the ejected blocks of the Lazial and Sabatine volcanoes, and the collection of decorative marbles and porphyrites used by the ancient Romans, were much admired.

Later in the day we examined the Museum of Geology and Agronomy at the "Istituto Geologico," in Via Susanna, under the able guidance of Cav. Ing. Zezi, the secretary to the Comitato Geologico (Geological Survey). The great variety of Carrara and other Italian marbles, the collection of building-stones and rocks, were duly admired. The interesting models of the Lipari Islands, Ischia, etc., were of great interest, and I

took this opportunity to draw the attention of those members who had lately visited the Aeolian Islands to their subaërial and also to their submarine conformation, pointing out how Stromboli is a very large and high volcano, half of it being submarine, and the origin of its Sciarra del Fuoco. Similar to Stromboli, Filicuri and Alicuri are seen to be composed of one or more semi-submarine cones, whilst Lipari is an exceedingly complex association of basic and acid volcanoes. The structure and physiognomy of Vulcano could be well studied on the raised model.

The next day (October 20th) being Sunday, the forenoon was devoted to St. John-in-Lateran and St. Peter's, and after lunch a number of other churches were visited.

On Monday, in carriages, we proceeded to the Capo di Bove, Signori Zezi and De Marchi acting as directors. In the quarries opened in the great lava-stream nearest to Rome, which flowed from the great Lazial volcano, some very fair specimens of nepheline were secured. The pozzuolana quarries, newly opened, close to the tomb of Cecilia Metella, were entered, and numerous good leucite crystals were collected. The Via Appia, the Catacombs of St. Calixtus, and the Circus of Maxentius were visited, in which latter the inner man was refreshed by a picnic lunch. In the afternoon the so-called pozzuolana quarries of the Tre Fontane were examined and a visit paid to the monastery and Eucalyptus plantations of the Certosa. On the return journey a stoppage was made at the magnificent church of St. Paul without the walls.

On Tuesday, October 22nd, we took the early train to Frascati, observing the peculiar facies of the Campagna Romana on our way. At Frascati, having provided the weaker of our party with donkeys, we made the ascent of Monte Tusculo, Signor Zezi and Prof. Portis acting as directors. The rock, supposed by the local geologists to be a lava, but undoubtedly in most cases, according to my own views, an altered and compacted scoria, which is locally known as "serrone," was seen to perfection. This rock has been very much used both by ancient and modern Romans as a building-stone, especially for posts, lintels, traves, etc. The ruins of Tusculum were finally reached, and lunch taken in the small theatre. Chestnuts were ripe, and we had filled our pockets with them: before lunch we made a fire of brushwood over them; and at the end of the meal

we had them ready roasted. From the summit of Tusculum Signor Zezi explained the configuration of the Alban Hills, and how the point on which we stood formed part of the rim of the great outer crater. The descent was made by way of Camaldoli and Monte Porzio, which latter is built on a parasitic cone, the form and structure of which can be easily studied.

Wednesday (October 23rd) was devoted to studying the rocks upon which the Eternal city is built, under the direction of Prof. Portis and Signor Clerici. At the Valle dell'Inferno, the directors drew attention to the fine section, in which three distinct beds were visible. The lowest, of bluish-grey sandy and fossiliferous clay, was the Pliocene marine clay ; superposed on this we have the second stratum of yellow colour, composed of beds of sand which are also fossiliferous and of Pliocene age ; and, lastly, the third or uppermost cap was of a darker yellow tint and consisted of materials of volcanic origin derived from the neighbouring volcanoes. Being specially permitted to enter the Farnesina, we descended to a brickyard, near which was a very fine section, similar to the last, and from which a rich selection of fossils was made. Here Sig. Clerici, who has devoted much time to the study of this formation, gave many interesting details.

On Thursday (October 24th), under the direction of Prof. Meli, we proceeded in train to Frascati, and from thence in carriages to Rocca di Papa, which is situated on the edge of the inner great crater-ring, often stopping to examine and collect. After an "al fresco" lunch, we ascended on foot to Monte Cavo, much of the way being over the polygonally paved road, made by the Romans, still in splendid repair. The constant occurrence of V. N. (Via Numinis) referred to the temple to Jupiter Latium which once occupied the summit, the centre of the annual pilgrimages of the Latin races who camped in the subjacent crater-plain. Monte Cavo is a small cone thrown up on the edge of the inner crater-ring which encloses the crater-plain just mentioned, which is known as "Campo di Annibale," although Hannibal never encamped here. Prof. Meli referred to a passage in Livy, which mentioned the occurrence of a rain of stones on the Alban Hills, supposed to be due to some eruption close by. The descent was made by way of the Madonna del Tufo, to Albano, where we passed the night at the Hotel de l'Europe. At dinner Mr.

T. V. Holmes, F.G.S., the President of our Association, said that he regretted having to leave us on the following day, and took that opportunity, in the name of the Geologists' Association and Geological Society of London, to thank Dr. Johnston-Lavis, and also Mr. L. Sambon, who had done so much to make this scientific excursion a success. He had greatly enjoyed his visit to that beautiful country, of which he would carry away an indelible remembrance. He drank to the prosperity of Italy; and as her volcanic fires were not yet spent, so he hoped that neither were those gifts which once had rendered her the first nation of the world. Profs. Meli and Portis, as also Mr. L. Sambon and myself, replied.

Early the next morning (Friday, October 25th) we took carriages to Genzano, and thence on foot made the whole tour of the beautiful Lake of Nemi. The party had the valuable services of Profs. Meli and Portis, to whom were added Signori Zezi and Tellini. The character of this crater-lake was explained, as well as that of Valle Ariccia, of which we had obtained a fine view. The latter has been filled up to its lowest edge by alluvium brought down from the hills above. Many interesting specimens were collected, including many varieties of peperino. After lunch at Albano we mounted to the edge of the Albano crater-cavity, which contains a much larger crater-lake than Nemi. Numerous ejected blocks, with haüyne and other minerals of contact metamorphism were obtained. The edge of the crater was followed to beyond Castelgandolfo. Just beyond this town Prof. Meli pointed out the vegetable impressions on the under-surface of the peperino which indicated its mud-like character when ejected. Descending to Marino, the numerous and extensive peperino quarries were visited, and our bags having reached the limit of what they could contain, pockets, greatcoats, baskets, and even ladies' mantles were converted into receptacles for the numerous heavy but interesting examples of rocks and minerals, with which we returned to Rome by the evening train.

Saturday (October 26th) saw us, with Signor De Marchi at our head, taking the train to Montecelio, near which, at Collelargo, are the quarries of Messrs. Maggiorani, worked in the Liassic limestone. In one quarry we found the old Pliocene shore-line, in which the limestone is bored by *Lithodomus* and *Clionia*, and presents other similar indications. Here we lunched,

being supplied with refreshments by the proprietor, to whom a vote of thanks was accorded. Returning we examined the bathing establishment of the "Acqua Albule." This spring, which forms a small river, sufficient to be utilized for mechanical power, is very rich in carbon-dioxide and hydrogen-sulphide. The former and the oxidation-products of the latter produce very remarkable effects upon the solution and deposition of lime in the form of travertine. Next we were conducted in a special train, provided by Count Giuseppe Savorgnan di Brazza, to his quarries of travertine, where we were joined by Signor Lanciani, the Professor of Archaeology in the University of Rome, who kindly gave us much valuable information of an antiquarian nature, from which we could glean the following: These were the ancient Roman quarries, from which the stone of the Colliseum, Basilica Julia, Castle of St. Angelo, and numerous other buildings was derived. They had but lately been reopened, and we were able to see a talus of travertine that had formed against the old quarry-face since Roman times. The area that had been denuded by the ancient workers was very great, as also were the mounds, or more properly hills, of *débris*. Even tombs of the ancient quarry masters had been met with. The method of cutting out and splitting off blocks of this rock, one of which was 40 c.m. in volume, was seen going on, and Mr. G. W. Butler, B.A., obtained some photographs of it. After Count S. di Brazza had liberally supplied us with tea, sandwiches and champagne to sustain us during our return journey, we entered our special carriages, which at Bagni were attached to the train to Rome.

After dinner the members of the excursion assembled in the salon of the hotel, where I gave the discourse which I had, on account of ill-health, been unable to do at Naples. The general arrangement of the Italian volcanoes and their geological age were referred to. The only rational theory that explains all the phenomena of eruption was in a few words described, and the different regions we had visited were recalled as illustrations of the theory.

Sunday, October 27th, was again given to the churches and antiquities of Rome.

On Monday, October 28th, in steam-tram, we took the road to Tivoli with Prof. Portis, Sig. Zezi and De Marchi as our leaders. We were met at Tivoli by Cav. Tomei, and taking

the ladies in his carriage he conducted us to the sights of the town. The beautiful Villa Gregoriana, the cascades, both natural and artificial, the Mesozoic limestones, and, above all, the formation, in some cases rapidly progressing, of calcareous tuff and travertine in and near the caves of Neptune and the Siren. After partaking of lunch, the different works that utilize the water-power were inspected, and on our return journey we drove through a new subterranean viaduct lit up by incandescent lamps, worked from the electric illumination station.

In the evening the members of the party issued an invitation to the directors of the different excursions, including Profs. Lanciani, Meli, Portis, Count G. Savorgnan di Brazza, Cavalieri De Marchi, Zezi, etc.

Dr. Drew, who had presided after Mr. Holmes's departure, said, in recalling the numerous and deeply interesting excursions that they had made, he could not forget the provinces and municipalities that had offered us hospitality, thus showing sympathy to us Englishmen and interest in science; still less could he forget the professors and friends who had directed and aided them in their excursion, and he wished especially to express his thanks to Dr. Johnston-Lavis and Mr. L. Sambon, who, with their wide information, their knowledge of the localities and their love for science, had known how to overcome the obstacles and carry into execution the programme that had been proposed. He was not only grateful to Dr. Johnston-Lavis for having promoted such an important series of excursions, but also for having added so much to the advancement of vulcanological science by so many years of disinterested study, with so much intelligence and so much enthusiasm.

Before finishing his speech, he felt it his duty to combat two false and preconceived ideas of English people regarding South Italy, viz., the laziness of the people and the insalubrity of the towns. Wherever he saw man, woman, or even children, they were working with great activity, and were working for little or nothing. Then at Naples and elsewhere, all had been to visit the magnificent Sanitation works, and he recalled the interesting discourses of Prof. Spatuzzi, Signor Sambon, and Dr. Johnston-Lavis, who had shown with statistical data how Naples was far healthier than many well-known European cities and that it had made an enormous stride in the last two or three years,

which brought it up to the level of sanitation which modern civilization requires. He, therefore, could not do better than wish Italy a future as glorious as her past.

Dr. Johnston-Lavis, in reply, said that he could only express his deepest thanks for the flattering remarks referring to himself and Mr. L. Sambon. He felt it an honour to have been useful to such a large body of scientific men and women.

Mr. L. Sambon said he was sure he should be interpreting the sentiments of all in expressing their gratitude to Comm. P. Boselli, the Minister of Public Instruction, who, patronizing this journey through Italy on the anniversary of the celebrated voyage of the great Spallanzani, had shown how much interest he took in science and the renown of the country.

Count G. T. di Brazza drank to the harmony of science, art, and industry, and to the friends of his country.

Prof. Lanzi said to the health of Old England, calling her the modern Rome, for her greatness was in her colonies, as was that of ancient Rome.

Signor Ingre. Demarehi drank to the lady members of the party, who proved how strong the weak sex were in England.

Mr. G. Potter said that as one of the three founders of the Geologists' Association, he was glad to see that on its 30th anniversary he should have been able to take part in the greatest and most successful enterprise yet undertaken by it, and he, therefore, in the name of that Association drank to the health of Dr. Johnston-Lavis, to Mr. L. Sambon, and to the professors of Catania, Naples and Rome, who had directed the various excursions.

The following day the party broke up, but a considerable number remained to see the sights of Rome.

In bringing this report of our excursion to a termination, I must first ask your pardon for the imperfections in the style and details of the account, which have been due to the very limited spare time at my disposal. In a considerable number of places it has been necessary for me to speak of myself, but although I should have wished to do otherwise, it would have rendered the account so disjointed as to have made it unsatisfactory.

Altogether, it may be said that the journey was made without any serious hitches, and even where some discomfort and displeasure were caused there was ample justification for them. A journey in Italy is not the same as one in England,

nor is one that lasts nearly two months to be compared with one of a week. Such conditions as a different people, few and bad means of communication, absence of hotels, along a track where it is considered the duty to impose on the foreigner, besides the want of punctuality and absence of those business habits on which so much depends, renders the burden of responsibility a most heavy one. Had I not had the kindest co-operation of my valued and many-gifted friend, Mr. L. Sambon, I am sure that I could not have made the excursion approach to a success. I take this opportunity in offering my deep gratitude for his valuable aid, when suddenly I found myself not only holding the helm of responsibility in the vast ocean of science, but amidst the reefs and breakers of administration. Lastly, let me thank the Association for the confidence it placed in me in putting in my charge such an important undertaking, and also for the kind tolerance towards me, when troubled by ill-health, worry, want of sleep and repose and unfavourable weather, of those who took part in it. In conclusion, let me wish success to this Association, which may be looked upon as the pioneer of its kind, and hope that this may be the first of a series of excursions to localities where the grand geological processes and phenomena are easy of access. Amongst such may be mentioned the volcanic districts of Iceland, the Auvergne, the Eiffel, the Tyrol and Hungary, the glaciers, lakes, and mountain sculpture of the Alps and Norway. I am grateful for the many valuable lessons in geology I have learnt through this Association, and there is little doubt that hundreds of others are equally or still more indebted to it.



CHAPTER II.

EOLOGICAL NOTES OF ACIREALE

by

SIGNOR GAETANO PLATANIA

MEMBER OF THE GEOLOGIST'S ASSOCIATION, etc.



Cireale is certainly one of the best head-quarters for a naturalist, especially those who wish to visit Etna. It is celebrated for the richness and variety of forms presented by the marine fauna and flora of its shores, particularly that stretch of the Sicilian coast from Sta Tecla to Acicastello. Neither is it less endowed in its extramarine fauna and flora, which assume in its neighbourhood a richness and quite a special facies. Acireale possesses a splendid climate which, coupled with every modern comfort, renders it preferable to any other centre for those who wish to study the natural history of Etna.

Much greater, however, is the importance of this city for the vulcanologist or mineralogist. In fact from Acireale the ascension to the localities of the most celebrated eruptions is as easy as from Catania, whilst trips to the Valle del Bove are much easier, as well as to the sites of the interesting and characteristic eruptions of 1852, 1865, and 1879. The neighbourhood of Acireale, with the tuffs, basalts and numerous and varied lavas are the most interesting points for the study of Etna.

In these notes of mine I propose to rapidly pass in review

the most important of these deposits, which makes Acireale a very rich, almost virgin and unexplored field for study.

The town stands about 170 m. above sea-level and is situated on a steep eminence called Timpa and composed of numerous sheets of lava and beds of tuff. A plain extends northwards, in part covered by the current of 1329 which reached the sea. Along the coast different mineral-water springs gush out, many of which have not yet been analysed. At Puzzillo is a spring of ferruginous water which is much used in Acireale, there is a magnesian one, and another at Stazzo also probably magnesian, whilst a saline one gushes forth from the volcanic rocks at Sta Tecla at 30 m. from the sea.

Beneath this lava stream of Sta Tecla a curious and rare object was found which is preserved in my own collection. It consists of a piece of wood, possibly the stem of a vine, which being enveloped in the flowing lava was carbonized and cracked in such a way that the magma from its great fluidity has penetrated the cracks, making a detailed cast of the wood which has now completely disappeared ¹.

Nearer to Acireale, at that part N. of the Balzo at the Timpa di Mortara, may be observed a curious prehistoric lava which has undergone decomposition into spheroids, so as to appear as being composed of so many volcanic bombs, piled one above another, and consequently compressed and crushed. Pieces of this lava scale off in concentric shells, more and more rounded, until a less decomposed nucleus is reached.

Under this interesting eminence, just to the E. near Sta Tecla and but a few centimetres beneath the surface, has been discovered an ancient lacustrine basin containing a great number of fresh-water diatoms. Curiously amongst these occurs the *Eunotia gracilis* sm. (= *Himantidium gracile*. Ehrb.) which so far has been found in lakes of great altitude above sea-level.

The N. part of the eminence of the Timpa of S.^{ta} Tecla is constituted of thick beds of tuff intersected by some horizontal sheets of lava. I have not, so far, collected any plant remains in this tuff such as are found in so many other tufts of Etna, and even in the neighbourhood of Acireale, but it is very probable that they

¹ Signor Gaetano Raciti has discovered in the lava of Fossa dell'Acqua, W. of Acireale, other less striking examples which present the same phenomenon. These he has very kindly given me, and are preserved in my collection.

exist. Near the town a prehistoric lava has been precipitated from the Balzo forming an enormous lava cascade, the surface of which is now capable of cultivation, and on which stands the Villa Belvedere. Amidst the scoria of this stream are to be found good crystals of Specular Haematite and vermicular silica, just as is the case in the middle of the town in the lava on which is built the Piazza del Duomo.

On the shore under the great cascade of lava is the celebrated Grotta delle Palumbe (Pl. XIII) excavated in a lava of earlier date and which presents a splendid prismatic structure. This Grotta delle Palumbe, which has been compared to Fingal's Cave in Staffa, although damaged by the fury of the waves, is still beautiful to see, with its walls rising straight up from the water and composed of radiating prismatic lava, whilst the bold and fantastic reefs which surround it form a most admirable passage.

Beyond the great lava cascade, the eminence (Timpa della Scala) is composed of numerous parallel beds of lava of different thickness, varying from 2 to 10 m. which dipping to the S. disappear beneath the sea. These old lava streams alternate with beds of red pozzolana. In the lower lava flows beautiful radiated Aragonites can be collected, white, pink, red-brown and green spheroids of the same mineral, together with Sphaerosiderite, Vivianite, Mesotype, Opal and Chalcedony. In one lava stream of considerable thickness near a bed of white tuff, in which vegetable impressions have been met with, are to be found beautiful examples of Olivine of a centimetre or more in size.

One fact worthy of notice is the state in which the large crystals of Hornblende occur in the lower lava beds. These crystals are sometimes cracked and the fissures have been penetrated by the magma as in those beautiful examples from Milo; sometimes the process is so advanced as to have reduced the crystals to fragments, more or less numerous, which are cemented together by the magma so as to assume an irregular polyhedral form. Around these crystals there often occurs a vacant space so that they can be easily detached from the matrix.¹

¹ It is of very common occurrence for a rough irregular solid body enclosed in lava to be surrounded by a cavity. The cause of it is undoubtedly the presence of a large free surface at which the evolution of H_2O and other gases in solution take place with ease and freedom, as illustrated by a crumb of bread in a glass of champagne.

Following the coast one meets with springs of ferruginous water very rich in iron ; which flow out from the rocks about 1 m. above sea level under the Timpa di Sta. Caterina, at a point almost inaccessible from the land side. A little farther on is the Timpa di Tamàso, celebrated for the aerolite which was seen to fall there. Gradually the cliff diminishes in height as Capo Molini is approached, upon which rises the ancient and renowned tower called Sta. Anna, and near which was wrecked the British Eclipse Expedition of 1870.

Leaving behind the smiling coast, which according to legend was the site of the amours of Aci and Galatea, the furious jealousies of Polyphemus, and passing the Capo Molini we soon reach the Port of Ulysses so celebrated by the Homeric poems, as also the seven reefs and islands which the enraged Polyphemus was supposed to have hurled at the daring Ulysses. The largest of these reefs, is the island of Lachea; it is composed of columnar basalt, dolerite and a metamorphosed clay to which Gemmellaro gave the name of Cyclopite. This island is renowned for the large and beautiful crystals of Analcime, which can be collected there in great abundance, and which in consequence of their very limpid nature and such fine water have been utilized as gems. The Analcime is also found as salbands to the dykes of dolerite which traverse the clay, and as a crystalline crust on the latter where in contact with the dolerite. The same mineral is found sometimes in such extreme abundance as at the Faraglione Grande as have given the name of Analcimite to the Dolerite which was filled with it and which in consequence becomes a remarkably hard rock.

In the island of Lachea and in the other Cyclopean reefs are to be found many other minerals, as for example Pyrrhotite in crystals, Pyrites, Chalcopyrite, Haematite (specular), fine scalenohedra of Calcite, granular Magnetite, rhombohedra of Dolomite, Siderite, Arragonite, Pyroxene with the variety Diopside associated with Anorthite, fibrous Tremolite of white, green and red colour, and Anorthite var. Cicoplite in flat tables (a mineral and not a rock), etc.¹

On the eastern side of the island of Lachea are to be observed, at different heights above the sea level, bands of rocks covered by serpulae and bored by lithodomi, which proves the re-

¹ I have also met with good crystals of Thompsonite.

cent elevation of this reef, just as that observed at Palmarola by Dr. Johnston Lavis.¹

The studies of Hamilton, Dolomieu, Spallanzani, Gemmellaro, Lyell and in fact almost everyone who has visited Etna, have advanced many theories to explain the formation of these rocks and have not yet exhausted the vast field of research which they offer to the naturalist, researches which render these reefs, already celebrated for the part they play in mythology, a sacred monument for the history of science.

The landing at Acicastello is beneath a cliff of beautiful globular basalt, (Pl. XII) which, like the neighbouring reefs, has also been studied by so many renowned geologists, is also rich in different minerals, and its peculiar structure has given rise to so many theories and hypotheses. Upon this cliff stands the historic ruins of the castle of Aci, glorious ruins that merit more care and preservation, and from whose walls one may enjoy a splendid panorama. By the side of the globular basalt projects a remnant of pelagonite tuff rich in beautiful zeolites. Amongst the most important minerals found in this tuff and in the basalt, the following may be mentioned, Chabasite in rhombohedrons, Garnet, Herschelite, crystallized and globular, Phillipsite, and finally Mesotype which some mineralogists believe to be a mixture of Natrolite and Scolecite, an opinion not accepted by Von Lassaulx.

Leaving the coast we first notice a deposit of clay which extends northwards as far as Capo Molini, westwards to Nizzeti, and which southwards is limited by a recent lava that has surrounded different basaltic hills and even the rock of Aci-castello. This Post-pliocene clay (according to Lyell, earlier according to Gemmellaro) contains little bands of Augite. From the midst of this clay rises numerous basaltic hills, one more interesting than the other, and which present such variety of structure, such mineral riches as to offer a vast field for the study of the Vulcanologist.

Without occupying myself with the beautiful prismatic basalts, sometimes extremely well preserved and at others more or less altered and crumbling; nor stopping to describe the fan shaped sections of the radiated basalts, which form splendid natural rock walls, I will devote a few words to the globular basalts of Acicastello and of these hills. These globular basalts may be divided into two categories, namely: 1st-the comparatively large, divided into

¹ H. J. J. L.—The Ponza Islands.—Geol. Mag. 1889, pp. 529-535.

prismatic wedges, radiating from the centre and sometimes articulated, 2½-in globular basalts with a concentric cleavage, of most variable dimensions, which sometimes enclose foreign rocks. Both are commonly found near metamorphosed tuff-beds and those nearest to these tufts present a thin vitreous cracked crust. The basaltic globes are often slightly deformed in consequence of the reciprocal pressure of one against another when they were yet in a pasty state. This, however, does not prevent the general existence of variously sized interspaces between them which is occupied by clay and tuff. Of particular interest are little globes of about a centimetre in diameter which consist externally of a vitreous crust, internally of basalt magma with crystals of Olivine, Pyroxene and Felspar.

All the basalts of Aci-Trezza and Aci-Castello are probably due to the injection of magma into a thick stratum of submarine silt, which occupies, as has already been said, the interspaces between the different globes. The globular structure is probably due to the phenomenon observed experimentally by Dr. Johnston Lavis that injecting into a dense viscous liquid (in this case the submarine silt) another dense liquid (basalt magma) this latter assumes the form of spheres with a narrow neck which may be divided leaving the spheres detached. Each globe has a different surface of cooling which with the consequent contraction extends from without inwards and divides the globe into a number of radiating wedges.¹

The globes at their periphery in which the cooling was most rapid are vitrified at the surface, being covered by a glassy crust, the formation of which was aided by chemical reaction between the basalt magma and the clay with which the former was in contact.²

The concentric cleavage which is often exhibited by the globular basalts is quite distinct from that produced by the decom-

¹ By using a coloured syrup and injecting into a liquid one, the coloured material spreads out in a cauliflower fashion but the whole mass looks like so many globes. A careful examination of globular basalts shows that many are not simple globes but rather pear shaped masses with a narrow neck which is often absent having been divided while still fluid. I have lately seen many beautiful examples illustrating this mode of production in my rambles in Iceland; parts of Cape Reykjanes serves as a good example. Ed.

² The author probably refers here to the pelagonitized layer covering the globes? Ed.

position due to meteoric agencies, as in the lava of the Balzo to the N. of Acireale. In this case the blocks of lava are irregular prisms of lava which shelling and cleaving, little by little, assume a spherical form until by cracking them one encounters a less decomposed nucleus.

In the true globular basalts the globes are preexistent to the action of meteoric agents, and independent of the latter, and the concentric cleavage also depends on the process of cooling, the radiating wedges, dividing into a number of joints, so that the the crusts, which in consequence of the columnar cleavage, separate into fragments which are generally prismatic, and simply represent the flattened jointed structure of straight basalt columns. No doubt at the same time meteoric agencies have aided in rendering the concentric shelling more evident.

Leaving the basalt hills and proceeding still farther from the coast to near Aci S. Filippo the clay beds, covered with numerous and enormous angular blocks of lava, is circumscribed by a step-like elevation formed of different recent lava streams. Upon it are situated smiling villages, elegant villas, and below at the contact of the lava and the clay numerous limpid springs gush forth.

Near Reitana fossil remains of elephants have been found by others, and I have collected some myself in a new tunnel now in construction. In this locality, at about 1 m. from the surface of the ground, occurs an interesting stratum of white pumice, much altered and already become friable. It has been said and repeated several times that no true pumice was to be found at Etna and it is in consequence of this that Prof. Basile maintains that this comes from the Lipari Islands; floated here on the sea.¹ A microscopic analysis and careful study of its mode of occurrence is likely to settle the question of its true origin². These pumices extend under the lava as far as Sta. Venera where there gushes forth the celebrated springs of sulphur water (Sul-phuro-saline-iodo-lithia-manganesiferous-hydrocarbonated)³. It is mainly to these waters that Acireale owes its great importance as a first class climatic station for the treatment of disease. The Ro-

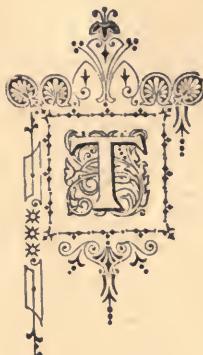
¹ G. Basile. — L'Elefante fossile nel terreno vulcanico dell'Etna. — Atti. d. Accad. Gioenia. Ser. III, Vol. XI.

² Either the Val di Bove is not a crater of explosion or true pumice that must have been then ejected should be found at Etna. Ed.

³ Silvestri O. — Sulle sorgenti idrogassose di S. Venera al Pozzo.— Catania, 1873.

mans built sumptuous *Thermae* near these springs, the ruins of which still resist the assaults of time. All around in this charming country, in different excavations have been found mosaics, statues, vases, coins, and other remains, which it is sad to see so much neglected by the Government and the Municipality of Acireale. This is still more the case, since the celebrated polemic concerning the origin of Xiphonia and Acireale would have in them so many precious documents to help in solving the question. Much praise is however due to the efforts of the *Accademia delle Scienze* of Acireale, which in the picture gallery possessed by it, proposes to incorporate an archeological museum combined with the little collection of natural history which also belongs to that body and which is being gradually increased.





CHAPTER III.
A SHORT AND CONCISE ACCOUNT OF
THE GEOLOGY OF VESUVIUS
AND MONTE SOMMA

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INTRODUCTION

Vesuvius during the last eighteen centuries has been looked upon as the type volcano and although from time to time rival claims have been advanced, this fire-vent of the Campanian Plain still maintains its supremacy. That this is the case doubtless is due to a combination of favourable circumstances. In the first place its situation within easy reach of one of the largest of the towns and seaports of the Mediterranean so that there is no part of the mountain that cannot be visited in one day's excursion out and back from Naples. The peculiar asymmetry in its shape, which, while striking to the eye as curious, is yet sufficiently simple to be readily comprehended. Its beautiful lavas, pumices, escarpments and numerous and varied dykes as well as its extraordinarily extensive and unique series of ejected blocks with their mineral contents, make the locality one of profound interest alike to the mineralogist and to the physical

geologist. Then again its continuous activity has fascinated the chemist and lead him to investigate its gaseous emanations and sublimates with as much enthusiasm as his scientific colleagues. Mineralogists, and perhaps still more geologists, are keen connoisseurs of beautiful scenery and have been seduced by the charms of the locality to devote more attention to the most important element in the beautiful land and seascapes of the Gulf of Naples. Last but not least, there are the innumerable associations with history and even romance, upon whose many many pages the classic name of Vesuvius is engraved; a name known to almost every school boy or girl in the civilized world. Its great rival Etna, many times its size, possesses neither the bold slopes, fine precipices, or beautiful situation of Vesuvius, whilst the products of the Sicilian volcano are but little varied and monotonous in the extreme. Still less can solitary, little varying Stromboli or its equally isolated though more interesting sister Vulcano, aspire to the enviable position of type volcano that Vesuvius with its majestic and elegant proportions is likely to continue to hold. It was on this ground that I undertook to prepare a geological map of the mountain on a very large scale which is now just published.

GENERAL DESCRIPTION

ERA A. — The Campanian Plain including what is now known as the Terra di Lavoro formed in Pliocene times a great gulf (at present represented by those of Naples and Gaeta) near the northern end of which rose the limestone island of Monte Massico and a few other detached masses and which extended in the form of narrow inlets amidst the calcareous Appennies, at the base of whose cliffs the waves of the Tertiary sea expended their fury whilst sands and clays were brought down by the rivers and deposited on the neighbouring sea bottom. Towards the end? of the Pliocene period, numerous volcanic outbursts took place in the neighbourhood of Naples. Whether the vent, around which Somma and Vesuvius were eventually piled, appeared before the first openings of the so-called Phlegrœan Fields is as yet undecided and is not unlikely to remain so. Probably coincident with the earlier volcanic manifestations of the period, the shallow pliocene sea-bottom was raised to somewhere *near* its present level and now forms the fertile plains of the Campania Felice.

What were the characters of the phenomena or of the pro-

ducts of Somma-Vesuvius when first it arose we can only judge of by analogy. We may therefore suppose that the first materials ejected were pumices, which were followed either immediately or at a somewhat later period by lavas. Amongst the ejected blocks of Monte Somma, Basalts, Trachytes and other rocks are met with that are not now seen *in situ* there. This fact leads to one of two conclusion, either that amongst the earlier products of this focus these rocks occur, or that previous to, if not during, the earlier existence of Somma-Vesuvius, such products had been spread over the area from neighbouring vents. Leucite which is the dominant and characteristic silicate of the lavas, etc. of this volcano in its more recent stages, may, have likewise characterised the earlier products, should the above mentioned rocks not be derived from this vent.

The plain which surrounds Somma-Vesuvius must he relatively much higher than when the volcano first manifested itself, for whilst the mountain grew up over 2000 m. (or 7000 ft.) the surrounding district must also, in the absence of rivers, have been raised by the adition of loose materials transported to it through the air, or by water as well as by lava streams some of which flowed great distances over it. Sections in fact conform this and demonstrate that considerable additions were also being made by the ejecta from the neighbouring volcanic vents. Now the height of the Campanian Plain around the base of the mountain is not very much above the present sea level and we have also evidence that not long prior to the historic period the sea level stood relatively much higher than at present, as indicated by the Starza and Castellamare marine terraces. All these facts indicate that Vesuvius was originally an insular volcano. The most striking proof that it has, in times past, been much more than at present surrounded by comparatively deep sea is the artesian boring at Ponticelli where I found leucitic lavas, scoria pumiceous scoria to occur to a depth of 177.25 m. (or 591 ft). These lavas were traversed from 59.90 m. (or 200 ft) to 105.44 m. (or 351 ft) from the surface or 80.44 m. (or 268 ft) from the present sea level and, if they really belong to Somma-Vesuvius a considerable inlet of the sea must have extended to near Pomigliano D'Arco sufficiently deep for the lavas to flow into. In well-borings at various localities around the foot of the mountain confirmatory evidence of this kind has been met with; in fact, Breislak a century since arrived at a like conclusion based on the latter evidence only.

Whether the leucitic pumices, pumiceous scorias and scorias

met with in the boring at Ponticelli belong to the initiatory stage of the volcano it is very difficult to determine, but at any rate they seem to prove explosive action at some period of its early history previous to the first outflow of the Somma lavas that are visible in the Atrio sections.

During this early stage of activity, or not unlikely previous to it, a gigantic explosive eruption occurred of a grey trachytic dust and fragments of black scorie, which now constitute enormous well-marked deposits over the whole of the Campanian Plain reaching from Gaeta to Salerno, from Capri to Avellino and Benevento and indistinctly represented at much greater distances. This material was ejected in all probability from a vent situated a short distance to the S. W. of Camaldoli of Naples that produced at the same time the piperno, a more fluid analogue of the pipernoid tuff.

ERA B. PHASE I.—That portion of the history of the Somma-Vesuvius volcano which is accurately known is that illustrated by the great section of the Atrio del Cavallo where for a height of 322 m. (or 1073 ft.) lavas, scoria, lapilli and dusts are seen piled one above the other and constituting one of the largest geological sections in Europe. All these lavas are comparatively basic and contain as a characteristic mineral leucite which ranges from microliths up to beautiful crystals over 1 cm. (or $\frac{1}{2}$ in.) in diameter. The other principal constituent minerals are magnetite and its allies, olivine, basic felspars as anorthite, bytownite, labradorite and much augite. These deposits represent, in section, part of the materials that were added to the great cone when it grew from about 600 m. (or 2000 ft.) to its maximum height of about 2100 m. (or 7000 ft.) and indicate a state of activity almost identical with that presented by Vesuvius from 1631 up to the present. At the end of the period of the formation of these ancient lavas, etc., the mountain must have presented the appearance of a beautiful symmetrical cone about 2100 m. (or 7000 ft.) high with the sweeping curves of its flanks only broken by parasitic cones, some of which can still be seen beneath the tuffs of Monte Somma.

The whole of the Atrio section is traversed by numerous dykes many of which no doubt reached the surface and there supplied parasitic cones and the resulting lava streams. Some of them are hollow or in other words the central fluid portion having drained out from some parasitic cone at a lower level on the flanks of Somma. Some even have been refilled and again emptied no less than three consecutive times.

Near the centre and lower part of this great section corresponding to the nuclear portion of the ancient cone all the originally loose materials such as scoria, lapilli, etc. are compacted and soldered together, no doubt in consequence of the original weight of the cone and the high temperature in the vicinity of the old chimney. The deposits of this age are also visible in most of the valleys of Monte Somma where they have been uncovered and cut into by denudation.

ERA C. PHASE II.—The great volcano next became dormant for some considerable time so that vegetable soil was formed on its surface and valleys were excavated.

PHASE III. *Period 1.* — Pending the progress of denudation above, the stagnant magma in the volcanic duct beneath was gradually dissolving H₂O (1) supplied from the surrounding aquiferous rocks until the tension of the solution rose to a point sufficient to overcome superincumbent obstacles and an explosive eruption occurred forming a crater which truncated the great cone. A very vitreous pumice of whitish colour mixed with the debris of the summit of the cone was spread over the surrounding country as a thin but most persistent bed of from 0.10 to 1.00 m. (4 to 40 in.).

Period 2. — Later as the magma rose from deeper sources, where it had dissolved less H₂O it expanded to a less degree, cooled more slowly and consequently became darker (chocolate) in colour due to the formation of microliths and numerous crystals of extratelluric felspars, amphibole, micas etc. The deposit of this scoriaceous pumice, or often pumiceous scoria, may attain as much as 4 m. (12 to 14 ft.).

Period 3. — Superposed upon the last but without any definite unconformity are beds of fine rounded lapilli in which the essential eruptive ejecta form the smallest portion and consist of fragments of dense, crystalline, black, pumiceous scoria an exaggerated crystalline condition of the products of *Period 2*. Rounded lapilli of dense leucitic lava, no doubt derived from the crater sides and ground up until small enough to be carried to the slopes of the volcano, constitute the most important constituent of the deposit; there are, besides, numerous yellow or brown much fumarolised fragments of similar rocks. The thickness ranges from 0.80 to 4.00 m. (2 $\frac{1}{2}$ to 13 $\frac{1}{2}$ ft.)

(1) The formula is used here as it denotes no special physical condition of the substance it represents. The phenomenon is analogous, at the temperature at which it occurs, to the solution of CO₂ in water, at ordinary temperatures.

Period 4.—The last described deposit sometimes passes up into, or may be represented by, a bed of very coarse leucitic breccia. This deposit is remarkably developed in the Vallone Pollena and Grande above Massa di Somma where the valley sides show a thickness of from 2 to 55 m. (7 to 64 ft.); In a purplish brown dust are numerous fragments of old lavas, scorias and other constituents of the great cone; the blocks of the first named often attaining some tons in weight. How these materials reached this particular slope of the mountain in such abundance cannot be determined; two alternative explanations, however, suggest themselves—either they are alluvial from the wash of the crater walls, having issued by the lower lip or a lateral baraneo of the newly formed explosion crater at the commencement of the PHASE; or they represent the last explosive efforts of PHASE III, ejected from some later opening which may possibly be represented by the depression between I Canteroni with the Observatory ridge and the mass of Somma. The internal arrangement of the materials is rather against an alluvial origin. It must be remembered that the main explosive crater must have been much smaller than that represented by the present Atrio del Cavallo.

From these deposits it is seen that PHASE III commenced with a violent explosion, which after excavating a crater and covering the mountain slopes with a white, vitreous, and later by a denser, darker, more microcrystalline pumice, the explosive action was reduced to grinding up the materials of the crumbling in edges of the crater cliffs and ejecting them as small fragments until most likely the vent choked. Probably after a short time the obstructing materials were suddenly blasted out giving rise to the *Period 4.*

PHASE IV.—As I have elsewhere explained the mechanism of eruptive action, we should expect that the direct sequence to the above phenomena would be the issue of magma from the chimney, no longer so rich in vapour as to be fragmentary, but in the form of continuous lava flows. It is the appearance of these lavas or the return of chronic activity which constitutes a new phase. What repair, if any, to the crater of PHASE III took place, nothing is known, but it is not unlikely that an eruptive cone of considerable height was built up though no lava streams seem to have overflowed the edge of the great crater, instead, radial dykes reached the flanks of the great cone and burst forth, building up parasitic cones from which streams of lava poured. Two of these eruptive apparatus are well shown in plan in the large geological map; that of the Val Sanseverino at an altitude of 375 m.

and one of the the Val. Von Buch where the eruptive cones are seen in section, whilst at a lower level on the slopes, the lavas that issued from the same are exposed in numerous ravines, indicated in the map by a brown tint. These lavas differ from the older ones of Somma in that their felspar is in considerable part a sanidine or near ally, whilst leucite is nearly absent and the lava, especially the earlier outflows, possesses a very fine vesicular structure more of a pumiceous than a scoriaceous character. At the Val. San Severino two distinct lava flows are superposed, the upper approaching much more the usual type, showing that the activity was still advancing towards the true Vesuvian character thus really representing two eruptive periods.

PHASE V.—What circumstances brought about a stage of repose in the volcano I can offer no suggestion, but that such repose did occur is proved by the numerous deeply weathered surfaces and vegetable soils subsequent to the last deposits and antecedent to the ejection of new eruptive materials.

PHASE VI. *periods 1, 2, 3, 4.*—The energy stored up during the preceding epoch of quiescence again resulted in explosive eruptions: no less than four of which occurred consecutively during PHASE VI. The description of each would here occupy too much space and for minuter details reference should be made to my original paper in the Quart. Journ. Geol. Soc. Lond. 1884. Each eruption was characterized first by the emission of lighter, whiter, more vitreous pumice with porphyritic enclosures of intratelluric or pre-eruptive formed minerals, principally sanidine, amphibole, mica and a little magnetite, followed as the eruption progressed by more microlithic, denser, and darker varietes with much pyroxene and magnetite dust and microlithic felspars but *with no leucite*. These beds of pumice contain also numerous fragments of old lavas, scorias, etc., constituting the remains of the great cone which was being eviscerated by a gradually enlarging and deepening crater. The apex of this crater soon extended down below the limit of volcanic rocks into the subvolcanic platform so that we find numerous fragments of fossiliferous quaternary (?) calcareous conglomerate, quaternary clays, mudstones and sandstones in the bottom of the deposits of *period 1* whilst the subjacent baked limestones were reached towards the end of that outburst. In later eruptions, especially that of *period 4* the crater apex had extended down to the deeper-seated limestones, often entirely converted into different silicates or ultrabasic rocks, so as to graduate into the very volcanic rocks that metamorphosed them. In fact these accidental ejectamenta

form a very important constituent of the deposits. I have estimated that at the end of the four eruptions the crater apex must have been 800 m. (about 2600 ft.) below sea level.

The third and last material ejected in all these explosive eruptions is a fine dust which is produced in part by the interstitial disintegration of the magma by the formation and escape of vapour, which, however, is then no longer sufficiently powerful to project any materials but fine dust so that they could fall on the cone sides beyond the crater rim. Some of the fragments of the cooled magma, materials from the crumbling crater-walls, etc. gravitating down to the crater apex where meeting at the bottom with the escaping vapours are by them churned and ground up and ejected from time to time as fine lapilli, sand, or dust. These dust deposits are often met with on Monte Somma, and possess a vesicular, pisolithic, concretionary, to false-bedded or even re-sorted structure due to their deposition taking place at a time when rain was falling more or less plentifully.

All these eruptions were prehistoric with the possible exception of the last, about which some doubtful legends are sometimes quoted. Each one did much to progressively excavate an extensive crater within the heart of the great cone, truncating it to nearly one half of its original height. The limits of this crater extend from about the 650 m. contour line on the S. of the mountain round the Val d'Inferno on the E., the eastern end of the Canteroni ridge on the W., and the great escarpment of Monte Somma that overhangs its remains, now known as the Atrio del Cavallo. The great Atrio cliff section is part of the old crater wall which may have slightly been re-pared by the first historic or plinian eruption. Some, if not all, of these outbursts occurred from an axis to the W. of S. of the one around which the old cone of Somma had been built up; a very common occurrence in volcanoes. The reason of this displacement was in all probability the resistance offered by the old plug of cooled lava filling the chimney and the greater height of superincumbent rock over the old axis of the cone. The crumbling in of the sides and the materials washed down from them soon filled up this great hollow nearly or quite to the level of the deepest notch of the lower edge of the crater rim in which state it was in the time of Strabo and Spartacus. Some old wall paintings found at Pompeii show us the cone truncated obliquely, due as I have said to the eccentricity of the axis or axes of the explosive eruptions. It is to this ruin of the grand old cone that the name of Monte Som-

ma is now understood by geologists, which corresponds to that portion of the mountain in existence up to the year A. D. 79.

PHASE VII. *Period. 1.*—In the year A. D. 63 a violent and destructive earthquake to a great extent ruined the town of Pompeii, which was followed by other shocks. In the month of November A.D. 79 another explosive eruption burst forth destroying Pompeii, Herculaneum, Stabiae and numerous villages and country houses. The materials then ejected are very similar to those produced during the earlier explosive eruptions with the exception of one very important character, namely, that all the pumice contains microlithic leucite in considerable abundance which not only is the case with this, but also with every subsequent eruption. We know from Pliny's account that the wind was blowing from the N. so that the pumice beds of this eruption are hardly recognizably represented N. of a line drawn E. and W. through the Punta del Nasone, the highest point of Monte Somma, whilst it forms very important deposits to the S. of that line, and especially to the E. where great quantities fell upon the limestone mountains of the Sorrentine peninsula, although the culminating point, M. Santangelo, is 166 m. (or 500 ft.) higher than the present summit of Vesuvius, that is to say 500 m. (or about 1500 ft.) above the lowest edge of the then crater. The characters of the ejectamenta can be beautifully studied in the streets of Pompeii where they are separable into three divisions of (1st) white vitreous pumice, 2m. (or 6 ft.); (2nd) darker microcrystalline pumice, 2 to 3 m. (or 6 to 12 ft.); (3rd) pumiceous dust, which is nearly always pisolithic and of variable thickness. At Herculaneum these several materials, mixed with others into one rather uniform paste, has gradually consolidated into a more or less compact yellow tuff, which attains a thickness of 20 m. (or 60 ft.) or more; whilst that covering Pompeii rarely exceeds 8 to 10 m. (or 25 to 30 ft.) and often is much less. At Pompeii the regular arrangement and stratification indicate that the materials fell through the air; whilst those at Herculaneum on the other hand owe their present arrangement to the action of water collecting and transporting the materials down some baranco or valley.

It is probable that this eruption, even at its commencement, did little to enlarge the preexisting crater but probably towards its close it built up a narrow, low crater ring within the great Atrio crater, thus laying the foundations of the new cone of Vesuvius.

PHASE VII. *periods 2 to 6.* — In the years A.D. 203, 243,

305, 321, 471 or 472 and 512 * eruptions are recorded from Vesuvius. The long intervals between each with no record of chronic activity intervening indicate that these were more nearly related to the explosive type of eruption and deposits of materials corresponding to such do occur at the Canale di Arena and many other spots. The different beds vary very much, but all present certain characters in common. In the first place the essential ejectamenta contain leucite in abundance. This mineral attains in these pumiceous scorias and scoriaceous pumices the greatest size and perfection so that beautiful crystals nearly 3 cm. in diameter are sometimes met with. The shorter intervals between the outbursts and the shorter time allowed for the solution of H₂O will account for this, as well as for the denser more microlitic and crystalline structure with marked increase in size of all the extratelluric minerals and the presence of fewer sanidines and amphiboles. One bed indeed is composed of a very vesicular scoria. In my original memoir an attempt is made to correlate these deposits with some of the above mentioned eruptions,

All the recorded eruptions of 1036, 1038, 1049, 1138, 1139, 1306, 1500, 1568 and probably many others, from what little is known of them, were of the paroxysmal, rather than the explosive type. It is not unlikely that the main portion of their products were fragmentary and went to build up the Vesuvian cone as represented in engravings before 1631. In fact the great developement of cone and small crater indicate with certainty the feeble disruptive power of these later outbursts. It is mentioned that in one or two cases lava flowed, but if so it probably was confined within the then unobliterated crater fosse between the new cone of Vesuvius and the great crater rim of Somma.

ERA D, PHASE VIII. In 1631 there occurred one of the most terrible eruptions of Vesuvius. It was not of the explosive but rather of the paroxysmal type and besides the fragmentary ejecta consisting of scoria, lapilli, sand, etc., numerous large streams of lava poured down the slopes of the volcano burning up in their course and burying towns and villages with a great destruction of life. Since that date the volcano has never been completely dormant for any length of time. Generally its activity consists of feeble but constantly varying explosions at the main vent,

* Since writing the above, evidence has been brought forward of an eruption in A.D. 780 when, from the description, lava appears to have flowed.

accompanied often by a slight dribbling of lava from some lateral opening near the summit of the great cone. This state is interrupted from time to time by paroxysmal eruptions which are due to the formation of radial dykes extending from the main chimney outwards to the slopes of the cone. As much of the lava as there is in the main chimney, above the level of the new vent, drains off immediately, thus lightening by so much the pressure on the remainder, which, consisting of a solution of a gas in a liquid, immediately on the pressure being reduced, froths up and issues forth after the first lava by the lateral outlet, whilst most of the vapour escapes up the main chimney. It follows therefore that, other influences apart, the outpour of lava is in direct proportion to the vertical distance between the original height of the lava column and the level of the new lateral opening, though the quantity is much more than that which was contained in the chimney above the level of the lateral opening. The principal parasitic cones now visible of which the dates of their formation are known are those thrown up during the eruptions of 1760, 1794, and 1861. The largest, however, is Camaldoli della Torre, which is certainly of considerable antiquity since the monastery built on its summit dates from a period earlier than 1631. I have never found any evidence that could fix its date more approximately except the following. On the coast opposite there crops out a peculiar and unique, fine, vesicular lava which is covered by some remnants of the pumice beds of PHASE VI. The resemblance of this lava to that of PHASE IV, the fact that it is earlier than Phase VI make it not improbable that it may be of the age of the former. In a well recently made at the foot of the Camaldoli cone, scoria much resembling the above mentioned lava was obtained and it may hence be suggested that they both issued from this spot. All therefore that may be said is that *probably* Camaldoli is referable in age to PHASE IV. The Fosso della Monaca, a deep conical hollow bordered by a rim of lava scoria, stands just above a lava-cake and scoria cone called Bocca il Viulo. They both appear comparatively fresh and, although their date is not known, there is some evidence to show that they were both points from which issued part of the lava in the 1631 eruption.

The lavas of PHASE VIII differ little from those of Monte Somma, the larger streams are generally finer grained because they have come from great depths and issue more quickly, whilst the smaller streams that dribble near the top of the cone are characterised by larger crystals, especially those of leucite, owing

to the long time allowed for crystallization whilst the magma is simmering in the top of the chimney. For the same reason the larger streams are generally very rough and scoriaceous on their surfaces whilst the shorter ones tend to have a corded surface since their contained H₂O has to a great extent been boiled off before they flowed out. The same arrangement and characters can be traced in the ancient lavas of Somma, only they often appear to be more leucitic since that mineral from the more advanced decompositien is whiter and more obvious.

During this recent phase of Vesuvius dense black lapilli has been spread over the slopes of the volcano for considerable distances and form deposits of considerable thickness. As we recede from the eruptive axis of Vesuvius the deposits of these lapilli thin out so that they offer no definite boundary line. I have, however, attempted to indicate on the great geological map the area where these lapilli form an important constituent of the surface soil by the red dots on green. The great screen of Somma seems to have confined their distribution to the N. and they extend much farther to the E. than the W. probably because strong winds were blowing in that direction during some of the great eruptions. The valleys and ravines on the E. N. E. slopes of Mt Somma are thickly clothed with a mantle of these lapilli so that few of the older deposits are visible.

SURFACE EROSION

The sides of Monte Somma are scored by deep valleys and ravines which were in great part cut out before the old Somma cone was truncated down to its present shape, as the valley depressions extend up to and notch the crowning ridge forming a series of serrations. Physically each valley may be divided into three sections — the upper third has the greatest fall but widest area and forms the gathering ground for the water which decends to the middle section, where from a slightly diminished inclination and the great head of the water, erosion progresses with great violence, cutting out deep and narrow ravines. As it decends, its energy has been gradually expended, it is charged with enormous quantities of solid matter (often 15 to 20 p. c.) and on reaching the lower third of the valley, where the incline is but slight, its speed is diminished and much of its burden is deposited as it flows on, though a considerable volume sinks into the porous soil. In consequence of this the solid materials, which had already been deposited in the form a dejection cone or alluvial fan,

eventually blocks the course of the stream, so that it eventually has to cut its way through this cone, forming a lowly inclined valley and bounded by almost vertical escarpments, locally called a *Lagno*, whilst the upper portions are called *Vallone*. The result of all this is that the upper section of the valley is almost uneroded, the middle section loses much material and therefore lowers the surface of the mountain at those levels, whilst the toe of the slope is pushed out on to the plain, so that the volcanic cone assumes a concave slope not due to subsidence as is sometimes supposed to be the cause. As long as the valley is being excavated in the soft materials these crumble away and leave sloping banks but when the old lava streams are reached and cut into, the sides then formed remain perpendicular so that the *Vallone* would consequently show a Y shaped section. When erosion extends down and through the lava beds which alternate with scoria and other fine materials, the valley bottom gets broken up into steps because the lava beds resist erosion and remain as ledges, which of course much impede any further rapid excavation. All these valleys are for the greater part of the year quite dry and it is only when the rain-fall is in excess of the rate of absorption by the porous soil that these valleys become water, or more properly mud, or *moya* courses.

Along the intervening ridges the usual foot-paths are made and on account of the incoherent nature of the more recent deposits (PHASE III, IV, V, VI, VII, VIII), the vegetation shield of the surface gets cut into and gives the rain and wind a fair start soon converting the tracks into deep narrow trenches often not more than 3 or 4 m. broad and 10 m. or more deep. This commencement of a valley, for it eventually becomes one, is called locally a *Cupa*.

During different great eruptions, the valleys have been choked by the ejecta and then cut out afresh, sometimes along a new axis; the *Vallone di Pollena* is a good example of this and a section of it to scale may be consulted in my original paper already cited.

Want of space limits this description rendering it very sketchy but it must be born in mind its only object is to give the reader an idea of the principal facts. Anyone requiring further details may, for the time being, conveniently refer to the following papers.

Phillips J. — *Vesuvius*. 1868.

Lobley J. L. — *Mount Vesuvius*. Second edition, London, 1889.

Johnston-Lavis. — *The Geology of Monte Somma and Ve-*

vesuvius being a Study in Vulcanology. Quart. Journ. Geol. Soc. Lond. 1884, Vol. XL. pp. 35-112, 2 wood-cuts and 1 coloured plate. — The Relationship of the Structure of Igneous Rocks to the Conditions of their Formation. Sci. Proceed. R. Dublin. Soc. 1886, Vol. V. N. S. pp. 112-156. — On the Form of Vesuvius and Monte Somma.—Geol. Mag., Dec. III., Vol. V., pp. 445-451, Fig. 1.—The Geological Map of Vesuvius and Monte Somma. Scale 1:10,000. With a short letterpress description. Philip & Son, 32 Fleet Street, Lond.





CHAPTER IV.

NOTES ON THE EOLIAN ISLANDS

AND ON PUMICE STONE

BY D.^r L. SAMBON



Prof. J. W. Judd published in the Geol. Mag. for 1885 an interesting series of papers upon the geology of the Lipari Islands. More recently. Doctor Johnston-Lavis in several publications as well as in the preceeding account has well illustrated the physical history of Lipari and especially the last eruption of Vulcano, the masses of obsidian and pumice ejected by it and spread in great abundance around the base of the cone, as fruit from the pine of smoke which rose as a gigantic mass from time to time from the crater, will always retain the expressive name of *Bread-crust bombs*. In consequence I should only repeat what has already been said were I to write upon the same subjects. I will therefore only give a few unpublished notes on the pumice and obsidian of Lipari and some legends of the locality.

The Eolian archipelago composed at it entirely of volcanic materials is of uncommon interest to the geologist. Its islands represent the summits of an extensive submarine volcanic region that emerges above the surface of the sea, and is situated between the phlegræan fields of Sicily and fertile Calabria.

The first formation of these volcanoes extends back to the early pliocene (astiano). Prof. V. G. Seguenza discovered on the N. coast of Sicily between Capo Orlando and Faro, opposite the Eolian Islands, stratified deposits of pumice, etc. mixed with numerous fossils which without doubt belong to that epoch.

One day, possibly during a dead calm, a frightful struggle commenced between fire and water. One can imagine an immense column of water rising as from a gigantic torpedo explosion, accompanied by clouds of vapour and fragments of rock, shutting off the light of day. On the surface of the sea, dark irregular waves covered with pumice, algae and dead fish, rolled towards the shore. At night great columns of smoke illuminated by lightnings, and showers of red hot stones, showed like an immense flame rising from a terrible conflagration. The enormous collection of dust, rock fragments and lavas accumulated and rose above the surface of the sea forming islands from which still flowed the lava.

Thus appeared these islands, as, in our own epoch, have risen Graham's island, Santorin and Sabrina. Many of these were soon destroyed by the waves, but where outflows of lava took place, the more compact rock was able to protect the looser materials from the action of the water. There have also been recorded in historic times the separation of large islands into smaller ones or the entire disappearance of one or more.

The orography of this archipelago must have continually changed from the time the first island emerged till the present day.

In the year of Rome 627 Vulcanello rose, and by other eruptions, was united to Vulcano in 1570. The great island of Eolia that once existed between Stromboli and Salina is now reduced to several different islets and reefs, ruins of the ancient crateric amphitheatre (1).

The islands that constitute the actual archipelago are the great monuments of its history. Every stone is an inscription or epitaph in which the geologist reads the details of this terrible battle of Titans.

Volcanic islands which at all times and places emerged or were destroyed, were certainly the origin of the many legends of *mysterious islands* which one meets with in reading medieval writings, and especially Arab Chronicles. Even Christopher Columbus speaks of capricious or enchanted islands which at

(1) See note to page 62.

times are invisible to navigators and at other times allow themselves to be seen, but never permit anyone to land upon them. These fugitive lands were also called St. Brandon's islands in consequence of the legend that this saint on his voyage to the Isles of the Blessed, landed with 17 devotees upon the back of a whale. The fear of demons and enchantments terrified the most courageous mariners the moment they observed any uncommon phenomenon. Before their minds was always the immense hand of Satan which often had emerged from the waves grasped ships and dragged them down into the abyss.

The actual Lipari islands present several eruptive centres of different periods, immense agglomerates and flows of a variety of products. Prof. Judd divides their eruptive cycle into three phases.

1st At first one great volcanic mountain was formed.

2nd Radiating from this central volcano three fissures appear to have been originated, and at various points along these fissures volcanic cones were thrown up, and numerous eruptions took place.

3. The apparently dying energies centred in this volcanic district were localized at two almost extreme points.

The products of these three periods are different. In the first we find various trachitic materials approximating to, but never reaching, the basalts on the one hand, and the quartz trachytes on the other. The second period is also formed of trachytic lavas, but there appears to be a constant tendency in them to graduate towards the rocks of the basaltic type.

In the third phase, whilst Vulcano is still active, ejecting very acid materials such as quartz trachyte (liparite), which often assumes the vitreous condition, Stromboli, the other active volcano at the opposite extremity of the group, gives forth materials essentially basic, as dolerite and basalt.

Nearly all these islands have the form of truncated cones. The most central is Salina, formed of two volcanoes which have a common base and are similar in form, in arrangement and height (1). The other isles are disposed along three radii more or

(1) To the N. W. side of the island the toe of one of these cones M. dei Porri has been drilled away by a large explosion crater, during the formation of which considerable quantities of a basic pumice was formed and spread over the island. These pumice beds exhibit the peculiar division into vitreous and microlitic varieties as first described by me at Vesuvius and elsewhere. More than a third of this crater ring has been carried away by the sea but the Scoglio Faraglione marks a remnant.

less straight which start, in fact, from Salina. Upon the N. N. E. radius lie Panaria, Basiluzzo, Lisca Bianca, Lisca Nera, Bottaro, Dattilo, and the Formicoli; so many ruins of a single volcanic island now destroyed, the largest and probably the oldest of the group (1) which now is only a great submerged solfatara, a drowning volcano, its last gasps a gush of carbonic acid and sulphuretted hydrogen rising in great bubbles to the surface of the water near Bottaro, which the sailors and fishermen call *Caldaie*.

Farther on is Stromboli, the great natural lighthouse of the Mediterranean, notable on account of its approximately circular plan and its constantly active crater. To the N. E., about a kilometre distant, rises from the sea with almost vertical walls a rock called La Petra or Strombolicchio, a great mass of very compact trachyte, the last remnant of another eruptive centre dismantled by the waves which, during a tempest, often cover it.

On the western radius is Filicuri, composed of two volcanic cones one much higher than the other. Farther on lies Alicuri, composed of a single cone with very irregular outline in consequence of the numerous lava streams, that reached the sea. So extensive is the growth of heather upon this island that its name is supposed to be derived from that circumstance. A great distance off is the small island of Ustica.

On the southern radius stands Lipari, formed of several volcanoes, irregularly arranged and differing in form, size, and age. Finally rises Vulcano, an immense ancient crater from the centre of which emerges the cone of historic eruptions. Near the northern ruined edge of the crater-wall is situated Vulcanello joined to it by a narrow neck of land.

These islands were called by the Greeks « Hephestiades » and by the Latins Vulcaniæ; the famous forges of Vulcan and his Cyclops. They were also called Eolian isles from Eolus whom fable raised to be god of the winds and who gained his reputation by predicting the weather from the smoke or the columns of vapour rising from the active volcanoes of his dominions. Even now the Liparites consult the summit of Stromboli and Vulcano, whose vapourous plumes, indicating the direction of the wind and the

(1) The popular idea was that this group was once a single volcano which to my mind is quite a fallacy for both Panaria and Basiluzzo are very extensive and well preserved remains of domes or mamelons of quartz trachyte whilst some of the islands are comparatively basic in composition.

hygrometric state of the atmosphere, are precious indications of the weather.

In the middle ages, when the wonders of mythology were no-longer received, religious legends were attached to these volcanoes and still live in the popular mind.

It is said that Theodoric was confined in the crater of Vulcano as a punishment for his sins. A monk of Lipari asserts that he saw him dragged to the island with his hands bound behind him, barefooted, and taunted by the unavenged spirits of the pope John and the Patrician Simmaco who hurled him into the burning crater.

When S. Calogero inhabited a hermitage on the island of Vulcano, he recounted to a pilgrim who went to visit him "Do know you that in this island are hollow places, full of wind and fire which escapes from certain apertures of this mountain commonly called the bocca di Vulcano; there one often sees going in and out demons in different shapes". In consequence of the devils becoming too insolent in the island of Lipari, S. Calogero himself drove them from the Montagna delle Pietre Nere, where they lived, They then took refuge in the stufe (fumaroles) producing terrible explosions, and in consequence even hence the holy man hunted them out and drove them into the crater of Volcanello, finally compelling them to give way to their rage in Vulcano.



The largest of the Eolian islands is that which the Greeks called *λιτασὰ* that is *The Splendid*. It is certainly one of the most beautiful among the Mediterranean Sirens — renowned for the variety and beauty of its rocks, the fertility of its soil, the mildness of its climate, the punice stone with which it provides the world, for its sweet currents, and its exquisite wine. At one time it was powerful, and its fleet was queen of the seas by which it dispatched splendid monuments of art, to Delphos in perpetual memory of its victories in the Mediterranean; — now it is a colony of convicts,

There still exist at Lipari, as remnants of volcanic activity, two thermal springs — one of about 60° C. to the left of Bagno Secco and forming a brook of such volume as at one time to serve as motive power to some mills; the other of 92. 5° C. in the valley of Bagni Caldi, where it issues from a cave and is employed for bathing purposes. In this western region of the island,

and especially in the neighbourhood of M. Mazzacaruso, the lavas and agglomerates have undergone much decomposition by recently extinct fumaroles. A few other unimportant thermal springs and fumaroles of aqueous vapour at a short distance from the city, and others seen by Mercalli on the S. E. flank of M. Sant' Angelo.

Of eruptions at Lipari there are no definite records, and it is doubtful whether we may believe *ad litteram* a codex of the XII century, recently discovered by P. Cozza in the Library of the University of Messina (N.^o 103, p. 168), in which, commenting the words of S. Patrizio upon subterranean fires, are added those which later were written by the monk Gregorio inspired by the sight of fiery volcanoes (1). "In this manner have spoken the saints: if some one does not believe, let him consider the island of Lipari which is so subject to fire that the sea boils to such an extent as to swallow up ships which happen to be there, whilst pitchy lava flows, and tremendous thunderings are produced. Then all Lipari trembles with the shocks, the sea sand on fire is raised even from the deeps to infinite heights and is transported by the winds to great distances".

"Some say that when it is known that some vile and iniquitous person leaves this life, then those places experience eruptions and thunder as if he had been condemned to expiate his crimes there".

"For at these places even I, Gregorio, passing after the sacred synod of Nicea, heard and saw these marvellous things".

What the old monk says of submarine eruptions is exact. At all periods we have descriptions of eruptive phenomena in the sea near the Eolian Islands, and in nearly all the eruptions of Vulcano the neighbouring water has become torpid and agitated by a multitude of big bubbles, with scoria and dead fish on the surface.

In the last eruption which the Geologists' Association witnessed, the submarine cable was broken three times since it was laid in 1881 between Capo Milazzo in Sicily. Dr. Johnston-Lavis first drew attention to this fact, and the details of the later ruptures were carefully published by Sig. G. Platania. The first

(1) The eruptive mouth and obsidian lava stream above Canneto which has a very recent look and is known by the name of Forgia Vecchia (old forge) which would rather indicate activity at that locality within the memory of man.

time was during the night of Nov 21-22, 1888, at 5.924 knots from Lipari. A considerable portion was then found beneath stones and mud. The second was on the 30th of March 1889. The cable was not broken; but, in the words of the commander of the repairing ships Robt. Greely, the central conducting wire was bared, the guttapercha covering softened, the jute involucrum worn away and the steel wires bared and eroded for a distance of about 90m. The cable broke whilst being removed from the water, although it should have resisted a much higher tension. At that spot it was observed with astonishment that the sea was 68m. less than the depth obtained in soundings made on previous occasions.

The third fracture occurred the 11 of the Sept. 1889. The cable was found crushed in several points but rather nearer to Lipari, and at one place it was entirely severed.

At the time of the first rupture the fishermen saw a boiling of the sea and much pumice in the water. On Nov. 27 at about 3 p. m. Signor Picone, who happened to be in a boat about 1 km. east of Vulcano, all of a sudden was nearly wrecked. The sea, that before had been perfectly calm, became agitated and boiling, whilst pumice floated at the surface. The boiling covered an area of 300 m. Contemporaneously Vulcano gave an explosion of stones and lightning.

This is not the only example of the breaking of a telegraph cable fixing the site of a submarine eruption.

The town of Lipari offers few objects of archeological interest. In the *piazza* near the quay is a statue of little artistic value but important to the Lipariotes as being that of their patron, St. Bartolomeo. It may be interesting to mention here the origin of the special favour in which this saint is held by the inhabitants.

Sicardo, a tyrant of Benevento, upon whose conscience weighed innumerable murders, rapes, treason, robbery, and torture, having learnt that superstition could make amends for crimes, sent envoys to all parts in search of bones and relics of saints; He had already collected many a treasure, when there fell into his hands a most miraculous relic, unequaled by any other. The Lombard ships which cruised about the isles chasing the Saracens in 838 found, on touching at Lipari, the body of S. Bartolomeo well preserved and entire in a marble sarcophagus which had come floating from the mouth of the Ganges to the Eolian islands; where, being recognized, and how should he not be!; altars were raised to him and he was adored, until

the musulmans spoilt everything. Of course the the saint's name is a very common one amongst the inhabitants of these islands.

We had hardly landed at Lipari when we were met by a little, badly dressed, bare-footed man, the guide Bartolomeo "un buon diavolo" who, the moment he saw Dr. Lavis capered about and showed his joy just as a dog does on meeting his master. We proceeded with him to a "cantina" where the excellent malmsey wine of Lipari soon restored our forces. We then decided to make the ascension of the M. della Guardia, to observe by night an eruption of Vulcano.

Bartolomeo collected several boys, not a difficult matter, for at the door of the "cantina" all the urchins of the place had gathered. The boys lit up large bundles of sticks to serve as torches and we started. The torches gave plenty of cheerfulness but little light, and the path was so bad that we often stumbled. Nevertheless we got up pretty quickly being urged by desire and curiosity.

It was a soft and serene night, without moon, but brightly lit with stars. The boys disputed for the torches which gave out showers of sparks; we chaffed each other whilst Bartolomeo, at the top of his voice, sang to a "buccuzza zuccharata, capilli riccia, ucchiuzzi sapuriti" (sweet lips, curly hair, and delicious eyes) Arrived at the top , we extinguished the torches , leaving only the lantern of Bartolomeo alight. The boys dispersed to pick grapes whilst we gazed into the immense obscurity in which with difficulty Vulcano and Vulcanello could be distinguished like two confused black patches. The roar of the waves was audible, and we asked each other whether it was not the boiling up of Vulcano. To the N. N. E. from time to time the fires of Stromboli shot forth.

In the Eolian islands there are several mountains called Monte della Guardia on account of the permanent sentinels that occupied their summits even up to 1830 to give warning of the approach of Saracen corsairs, who often came from Algiers and Tunis on predatory excursions.

A story is told that once upon a time a large fleet was signaled, and the poor desperate Lipariotes addressed their supplications to S. Bartolomeo ; who appeared with a knife in his hand, and ascending to the castle cut some leaves of the fig cactus which he threw into the sea. These leaves immediately turned into so many ships, upon which the Liparotes embarked and chased off the pirates away.

For more than an hour we remained sitting on the ground

awaiting an eruption, and were just on the point of leaving when at 10.30 p. m. the crater of Vulcano exploded with great violence, liberating immense volumes of vapour. In the gigantic smoke column we saw five successive flashes of lightning of a clear azure color, and shortly after was heard the thunder mingled with the roar of falling stones. The lava fragments thrown on to the slopes of the cone retained for some time their incandescence of a dark red colour. Farther off to the S. W. the scoria set kindled the broom-bushes, from which rose brilliant flames forming a striking contrast to the dark red reflection from the column of vapour. In a few moments nothing was observable except a cloud of dust which the wind spread across the starlit heavens.

In returning on board our steamer we were again feted by Nature's fireworks, every stroke of the oar, every shake of the cables produced phosphorescent tipped waves of rare beauty in consequence of the great abundance of *Noctiluca miliaris*.

Some products of these islands particularly interest visitors from northern climes, and perhaps a few notes on some of them may be of interest to future travellers.

The *Opuntia ficus indica* "fichi d'India" or prickly pears, a plant of South American origin, grows in great abundance in the Eolian islands and all Sicily. They form long impenetrable hedges and often wall in the farms. The fruit of this plant is often the only summer nourishment of the peasant. In the Piazza of Lipari where the market is held, stand rows of peasants behind baskets full of this fruit. The moment a customer approaches these sellers remove the skin of a dozen *fichi* with incredible dexterity. Even if several customers come together, however quickly they may swallow the fruit, the seller does not allow them to remain empty handed.

At the time of our visit the convicts could be seen running about with large willow or bamboo baskets full of the little blue-black grapes of which our so called dried currents are made. The heat, our thirst, and the sweetness of these minute grapes made us play havoc with numberless bunches. To make currents the Lipariots pick the grapes when quite ripe, throw them into a lye made from wood-ashes of varying strength according to the maturity of the grape, and then dry them in the sun.



All the best pumice of commerce is obtained from the north-east region of the island of Lipari extending as far as the

summit of Mt^e S. Angelo on its northern slope. The quantity is prodigious that was ejected during the eruption of Campo Bianco. It is excavated at the Fossa Castagna near M. Pelato, at M. Chirica, and on the shore of the Mosche.

I visited a quarry of M. Pelato on the outer southern side. The height was about 1·50 m. and 1m. large. The entrance was sustained by poles, faggots of brushwood and stones; at first one descended for 160 steps, then one ascended for about 50 m. where two naked men were digging in the dull light of an oil lamp. In decending I met some young men who were carrying up baskets full of pumice. They wore short coarse linen drawers, and on their naked breast hung the blessed scapulary. On my arrival at the workes they made me sit down on an empty basket while I watched the men dig out the pieces of pumice, often the size of a human head, from the imbedding matrix, which is composed of different sized fragments and dust of the same material, pressed together, and forming an incoherent tuff. They told me of their poor wages, and the dangers of their work in consequence of the frequent collapse of the workings, killing men and youths. It was horrible to hear those accounts of misery and misfortune at the bottom of these caves.

The low roof and narrow passage from which every moment fragments detached themselves seemed to threaten the collapse of the whole; and it was with great relief that I again reached the daylight. Only a few weeks previously a quarry of M. Pelato had collapsed and buried some workmen, and more than two days work were required to reach them. These unfortunate men, saved by a miracle, returned again to their work, for what else could they have done to obtain bread?

Prolonged and curious was at all times the discussion concerning the origin of pumice. It was believed to be amianthus decomposed by fire by Pott, Bergman and Demeste; calcined lignite or schist by Vallerio; scorified marl by Sage and granite that had become blown up and fibrous by the effect of fire and water by Dolomieu (1). The latter asserted having found enclosed in some pieces of pumice fragments of granite. He also declares that he had seen masses of granite which took on gradually the

(1) It is wonderful how nearly correct was the assumption of Dolomieu when chemical and geological science was in its infancy. The cutting satire of Spallanzani is often equalled or surpassed by more modern Italian scientists at the expense of foreign investigators and often as little justified. EDITOR.

fibrous structure and other characters of pumice ; so that he concluded that granite or granitoid schist was the primitive material which by the effect of the volcanic fire passed to the state of the pumice (1). Finally he declares he sent specimens to all the most learned geologists of the time. Spallanzani , who visited that same locality and hunted in every part of Campo Bianco in a most diligent manner but without being successful in finding the granite of Dolomieu, says wittily that probably the French geologist had carried them all away. Spallanzani himself, on the contrary , considers that pumice and obsidian are the result of fusion of great masses of intermediate lavas which one encounters on all parts of the mountain. Prof. J. F. Blake recently, probably ignoring the observations of Spallanzani, is satisfied in finding in that locality "Mother-pumice" as he has baptized it, from which also is derived the obsidian. But pumice, obsidian and all intermediate rock varieties more or less scoriaceous are but different forms of the same eruptive product. The whole history and modifications of pumice have been worked out by Dr. Johnston-Lavis, who has shown that by studying these eruptive products the whole mechanism of volcanic action in general is explained and the sequence of eruptive phenomena of any volcanic focus can be made out.

The eruption of Campo Bianco was certainly of a very violent character , as we can judge from the great quantity of pumice and the enormous stream of obsidian.

This obsidian is at its surface scoriaceous and often almost pumicaceous , because here , pressure being least , the remaining vapour could expand into bubbles which were prevented from escaping by the cooling and viscous glass. Thus we see extensive scoriaceous crests where the escape of vapour was greatest. The whole surface is split into great irregular slabs of all sizes, with edges curved, contorted and often folded back ; whilst the slabs are cracked by the cooling, and the surface reddened by oxidation so as to look like the bark of a tree.

The interior of the flow is also heterogeneous from the presence originally of major or minor quantities of vapour, the

(1) It is not unlikely that Dolomieu encountered some fragments of partly fused granite, and quartz and felspar inclosed in the pumice. Such inclusion partly fused constituted numerous nuclei of bombs in the two last eruptions of Etna. We found the same in the ejectamenta of Vulcano and I met with a lava stream at Stromboli crowded with such as also the rock of Strombolicchio.

Editor.

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more or less rapid cooling, and greater or less pressure. Where cooling was slow we find the glass full of spherulites of different size, from the smallest up to that of a Barcelona nut, composed of needles of quartz and felspar arranged in rays. The crystalline mass of the larger spherulites is arranged in so many concentric layers, onion fashion. Often between these strata, spaces are left, upon the walls of which crystals of tridomite, fayalite and magnetite have been deposited. The large hollow spherulites are the lithophysae of Von Richthofen. The obsidian sometimes is crowded with spherulites whilst at others they are rare. Often one finds these bodies arranged in bands interstratified with laminae of pure glass, of porcellanite or of scoria.

These strata are derived from the spreading out of the fluid lava which at the source was expelled in irregular jets or gushes. In consequence, the greater the extension the particular gush was spread over, the thinner will be the lamina. In more liquid and homogeneous rocks such as the basalts, the successive lamination is less marked than in the acid lavas which are viscid and less homogeneous. If cooling takes place more slowly and under great pressure, the obsidian assumes a perfectly lithoidal aspect. Amongst the numerous obsidian streams which we know of, are of especial interest those of the Peak of Teneriffe, a torrent 15 km. long, and that of the Yellowstone National Park, where the rock occurs in enormous prismatic masses. Campo Bianco, with the flow of the Rocche Rosse, was the last effort of eruptive activity in the islands of Lipari.

When we descend to the shore of the Baja delle pomice by the gorge to the S. E. of the great obsidian flow, the slopes facing the lava are composed of immense deposits of pumice in which hundreds of holes are observable, marking the excavations made in search of the larger masses of this valuable rock, much of which could be seen in the numerous baskets standing at hand. The sight of the enormous agglomeration of pumice and dust of a glaring white colour, cut by the action of rain and wind into fantastic shapes, stands out against the blue sky like the irregular crags, spurs and ridges of a great glacier.

Along the marina are quantities of pebbles of pumice, either rounded by the torrents that descend from above or by the waves that lap the shore. When the wind blows from N. E. a veritable fleet of floating masses reaches the port of Lipari (1). The

(1) I have picked up considerable quantities on the beach at Bagnara and other points of the Calabrian coast.

EDITOR

pumice that has been excavated is carried to the beach, and stored and sorted in sheds or caves cut out of the same pumice tuff, protected in front by a breakwater of big stones to prevent heavy seas reaching and washing away the produce.

Pumice in commerce is classified as follows — *grosse* (large size), *correnti* (medium), and *pezzani*; (small); the large and middle size are subdivided into *lisconi* (flat) and *rolondi* (round). The *lisconi* are filamentous (1) and break less easily than the *rolondi*. They are also trimmed by the sorters. The *lisconi* and *rolondi* are again subdivided into white, black, and uncertain, according to their colour.

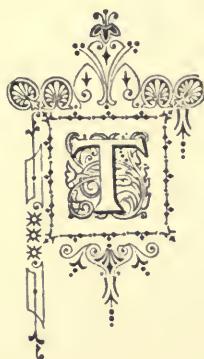
The price varies according to the quality from 50 to 2000 lire the ton. The common price for the assorted is 350 to 500 lire the ton. As much as 5000 tons a year are exported. The best pumice is that of Campo Bianco. It is also obtained at Pererra, but it is in small quantity and was produced at the eruption of the Forgia Vecchia. It is a first class grey pumice and fetches from 600 to 750 lire the ton, and does not so easily break as that of Campo Bianco. Also at Vulcano a grey pumice is found but the presence of included crystals render it useless for commercial purposes. At Castagna a commoner pumice is obtained called *Alessandrina*, of which brick shaped pieces are made and used for smoothing oil-cloth.

As we quitted the port of Lipari on our return to Messina, the narrow strait dividing that island from Vulcano, recalled the legend which recounts that these two islands were once joined and that continual and frightful eruptions of Vulcano compelled the inhabitants to supplicate the assistance of S. Bartolomeo, who thereupon came down from the clouds with a big knife and divided at one cut Lipari from the turbulent Vulcano.

It was nearly night when we were steaming fast away, leaving this weird and strange land behind when a tremendous explosion from Vulcano occurred and as the gigantic dust column rose it cast its long shadow across the sea. Each bale of dark smoke was tinged with gold from the setting sun. It seemed the farewell salute of Titan in honour of our visit. Vulcano saluted us thus, roaring and glowing, whilst on our part we enthusiastically applauded this final demonstration of volcanic energy.

(1) That is the vesicles have been pulled out in one direction.





CHAPTER V.

HERMO-MINERAL AND GAS SPRINGS OF SUJO

BY

Dr. H. J. JOHNSTON-LAVIS



That part of the Roccamonfina volcanic pile known as the Monte Cortinella or Monte la Frascara which is the analogue of Monte Somma of the Vesuvian volcanic massif, slopes down and away from the crater towards the W. Its toe abuts against the steep declivities of a range of calcareous hills so as to form a rather narrow gorge through which flows the turbulent Garigliano. This valley or more correctly gorge is known as the Valle di Sujo from a small village and ruined feudal castle that caps a limestone eminence and guards its southern extremity.

Its length is about 8 km. and the Garigliano, in its course

(1) A local tradition attributes these rapids to large blocks of stone thrown in by the inhabitants to prevent the ascent of the Saracens in their marauding expeditions.

through it , falls about as many metres though in a step like fashion, in consequence of which the rapidity of the flow is very great and at certain steep parts distinct rapids are formed. (1) Besides these, the valley possesses several other orographical and geological characters well worthy of attention. Its western side is constituted by the gentle slope of the volcanic flanks of the early great cone of Roccamonsina, composed chiefly of extensive lava flows of Leucitite and Leucotephrite with less important and more recent Trachytes and Leucitophyres , together with various tuffs and other fragmentary volcanic materials.

At a few points close down to the river, coarse grit-stones and conglomerates of a very heterogeneous nature, crop out and at one point near the spring of the Acqua Ferrata (Iron water) several parallel , long, lofty tunnels have systematically been cut into the mountain side. The entrance to some of these have been stopped up, but the chambers are accessible by the cross passages joining them some distance in. None of the inhabitants of the neighbourhood are able to give any information regarding their origin, but numerous fables are springing up regarding them. My friend Dr. L. Sambon, myself and my son Marcus are probably the first who have explored them in recent times, an undertaking not difficult but very unpleasant from the insupportable odour arising from the abundant deposits of guano of bats, who in thousands inhabit these caves. These excavations are undoubtedly of the nature of quarries as proved by the partly or entirely detached or worked blocks to be seen at the working faces at the extremities of some of them. Their shape is identical with similar quarries in the tuff of Naples, that is to say a high lanceolate arch slightly truncated at the top. The amount of material extracted is sufficient to have built a large town, though none such exists, actually or in ruins, in the vicinity , and therefore we must conclude that the materials were carried to the neighbouring river banks and floated down to Minturno or else, where when required. Some of the numerous feudal Castle towers of the neighbourhood are pointed if not built of a similar material. Certainly these quarries must be referred to medieval times or might even belong to the Roman period, though the neighbouring baths of that epoch are chiefly constructed of brick and tuff.

But to return to our main subject — the volcanic slopes are carved out into radiating ridges and valleys as usual in long extinct volcanoes, which are now covered by rich fields and olive plantations low down, and chestnut woods near the summit,

but the flora always shows distinct indications of the volcanic nature of the soil rich in potash and phosphates.

The western side of the gorge presents quite different characters. It is composed principally of the usual fine-grained dense crystalline limestone of the region, probably of cretaceous age, which constitutes steep precipitous slopes of from 200 to 250 m. high, in most places thickly covered by ilex trees and bushes, myrtles, prickly oaks, etc. characteristic of the poor and scarce limestone soil, which is also indicated by the absence of fields or gardens. In fact the contrast between the two sides of the gorge is most striking, at the same time adding to the variety and beauty of the landscape. As on the eastern bank of the Garigliano we find small inliers of sedimentary deposits so on the western bank we encounter patches of volcanic rock. This, I believe, is not a direct derivative from Roccamontfina but simple remnants of that great deposit of fluoriferous dust that was ejected from near the Lago d'Agnano and spread over the whole Campanian plain, and far over the mountains that form its boundaries. This dust was eventually washed down into the depressions where it attains its greatest thickness forming taluses at the foot of the hills. Where these latter consist of limestone, the loose fragments of that rock that have been carried down with the wash of rain and mixed with the dust have undergone the usual fluoriferization and silicatization that we meet with in the resulting tuff in all parts of the region of its distribution. This dust eventually consolidated into a compact, sonorous, pipernoid tuff, very suitable for building purposes. The pipernoid structure due to the presence of fragments of black scoria is very poorly marked in the neighbourhood of Sujo and Roccamontfina as the distance from the eruptive centre was such as to allow only the grey dust and very small fragments of scoria to reach so far. This tuff forms a thick mantle on the lower slopes of Roccamontfina, where the fluoriferized limestone fragments are absent but near the Stabilimento delle Quattro Torri this tuff is rich in those inclusions, which can be well seen in the pits from which the stones for that building were obtained and where the tuff abuts against the limestone hill.

The steeper inclination of the western side of the valley is due in great part to the constant pushing forward of the toe of the eastern slope, originally from lava flows, etc. and later from the constant wash down of the abundant loose materials from the volcanic flanks. This of course has tended to shelfe the Garigliano

against the limestone, which being more soluble and less resistant than the lavas, has tended to be undercut.

It is along the foot of this western valley side that the larger part of the numerous mineral springs and gas exhalations take place. It may be that the gorge of the Garigliano is a line of faulting, as suggested by Sig. Moderni, along which the springs issue, but the probable cause is that the toe of the Roccamonfina volcanic pile is lower here than at any other part of its circumference, and therefore it is here that the subterranean drainage level reaches the surface. No doubt many of these springs might flow out at a higher level but are impeded by the comparatively impermeable tuffs, whilst they find a facile passage at the junction of the latter with the easily soluble limestone. There are, however, several other springs around the foot of the volcano as at Francolisi, Teano, Riardo, etc. but as these issue at a higher level they are less voluminous, less mineralized and colder. The north and north east toe of the volcanic pile possesses hardly any springs that can be considered mineral, since it is here that the highest levels are reached.

In connection with this is a curious absence of any important alluvial deposits along the sides of the valley, and also its narrowness in proportion to the strength and volume of the Garigliano. In the next place we find the whole valley of the Liri (name of the Garigliano before it enters the Valle di Sujo, lined by abundant lacustrine deposits which indicate its ancient lake like character. These facts have led Ferrero and others to doubt the present course of the Garigliano to be other than quite recent. It is supposed that the ancient lake emptied itself on the other side of the volcanic pile near Presenzano where it would have to pass a barrier now 194 m. above sea level at the Tav.^a S. Felice.

It is not unlikely, however, that the original course lay somewhere under the present volcanic massif which was built up in the channel and so compelled the river to seek a course to the right or to the left, as the foot of the volcano was raised first on one side then on another by fresh lavas or tuffs. This, as every one knows, is an exceedingly common occurrence where rivers flow in the vicinity of volcanoes.

We have no evidence of Roccamonfina having been active within the historic period and the general facies of the progress of decomposition of its rocks, which much resemble those of Monte Somma, is such as to lead one to judge of its greater antiquity and as the activity of the latter only doubtfully reached

the very dawn of the historic period, we may safely consider Roccamonfina as prehistoric. In consequence of this, there is good reason to suppose that the great volcanic neck with its subsidiary radial dykes, with possibly separate and smaller canals or necks, have undergone a very considerable amount of cooling, although we know that the process is an exceedingly slow one. These masses of hot rock that traverse and are therefore in contact with the subjacent limestone, react upon and metamorphose it. This change practically consists of replacing by silicic acid the carbonic which escapes in an upward direction where it encounters the percolating waters from above and is in part dissolved by them. The resulting solution will depend on the supply of gas, the depth, and temperature of the rocks and gas. In addition to the carlonic acid, other gases are also concerned and are in part derived from sulphurous impurities of the limestone being metamorphosed, and in part as gaseous exhalations from the cooling igneous magma. This solution will follow the lines of least resistance and attack the rocks it traverses ; the leucites and felspars of the old lavas and tuffs will afford potash, soda, magnesia and lithia, the magnetite will afford the iron, and from the limestone, lime, magnesia, etc. will pass into the solution.

The resulting liquid will be more or less cooled in its passage through the colder rocks or by admixture with other water, but from its density it will flow at the lowest level. Where pressure becomes less, some of the dissolved gasses will issue from the ground forming small *mofete* (1) and much more will be disengaged after its appearance at the surface, as is well illustrated by the Grande Inferno close to the exit of the cold Sorgente di Acqua Sulfurea (Plate XVI). Besides these, hot and cold gases will reach the surface at variable temperatures and pressures so as to constitute solfataras, soffione, etc.

As we follow the north and eventually the west bank of the Garigliano when we approach the *scafa* or ferry, beneath a pointed hill on which stands the small village of Sujo overtowered by the picturesque ruined feudal castle, we begin to meet with the springs of mineral waters which form brooks sufficiently large to drive mills. As we ascend the valley it rapidly narrows

(1) By the Italian word *mofete* is understood carbonic acid in such quantities as to form gaseous lakes in wells or other depression in the earth, of which the Grotto del Cane near Naples is a well known example, but which is far surpassed in this region under consideration.

and every now and then we cross a fresh brook, the stones at the bottom of which are of a brilliant white, tinged with a faint yellowish green, due to the deposited sulphur from the decomposing sulphuretted hydrogen of the water. For the same reason the water soon assumes a milky opacity whilst the air in the vicinity smells strongly of the gas. As we round the limestone buttress, other springs are met with, and at one point on the river banks a whitish bare spot is seen marking the site of a gas spring of carbonic acid and sulphuretted hydrogen with deposits of sulphur.

The next point that strikes our attention is a rectangular reservoir lying just beneath the path at the level of, and only separated from the river by a small wall built of loose limestone blocks. If the partly tepid water within has not been disturbed for some hours it assumes a milky bluish colour and is in a constant state of ebullition from the abundant escape of gas. This spring is one of the greatest favourites amongst those who resort to this region; its tonic effects upon the skin and indirectly on the whole organism is most remarkable even after a single bath. We found that after a long days geologizing in the broiling sun, five minutes of this bath had more restoring properties than we had ever experienced from any other kinds, sea bathing included.

But a few paces farther on, we arrive at the sulphur water spring called the Caselle which occupies a somewhat similar position to the last, except that the distance from the river is a little greater, a canal over 2m broad of from 1 to 2m. deep carrying the abundant overflow of water to the Garigliano. The basin of the spring itself can only be compared to a gigantic glass of champagne just being poured out, as can be seen by (Pl. XVI.)

This spring is the favourite drinking water, and certainly deserves credit for being most refreshing and palatable, although containing much sulphuretted hydrogen, the taste of it is very well covered by the pungency of the carbonic acid. Immediately above and to the W. of the path, close to the spring, is a basin shaped depression, at the bottom of which descends a deep hole. The form varies, for on account of people loosing their life here, it is each year filled by the authorities previous to the bathing season but is reopened by the undermining of the river, the neighbouring spring and escaping gas. When only a moderate wind is blowing the whole of this basin is filled by carbonic acid and a little sulphuretted hydrogen gas, which overflows the lowest edge and falls as a cascade down the road, as can be seen by its

extinguishing a lighted match placed near the ground. Around the walls in the deeper hole a thin layer of sulphur is deposited. Numerous lizards, moths, etc. can always be seen lying dead at the bottom. This is locally called the Grand Inferno. At numerous points along the road the limestone is, in part or whole, converted into gypsum by the action of the oxydised sulphur compounds of the mineral exhalations and waters.

Immediately beyond this spot the alluvial plain broadens out to a hundred metres or more, forming one of the widest of its kind within the gorge. Just where the valley again begins to narrow, the Stabilimento delle Quattro Torri has been built, containing over twenty rooms for the accomodation of the bathers. It is to Signori D'Orvè and Cimino syndics of Castelforte and other local proprietors to whom credit is due for this enterprise. The situation is most picturesque and with a little improvement should form the centre of the Spa region. We now enter the narrowest part of the gorge and can hardly walk a hundred paces without encountering either mineral springs or indications of them; a little farther on we come to the Stabilimento della Provincia built over the richest spring, especially in iodine, of the district. Close by are medieval ruins probably constructed for the same object and but a few hundred yards farther we meet with very extensive remains of Roman Thermæ, almost a small town (Pl. XV.), which with most laudable energy Sig. Duratorre, the owner, has uncovered at his own expence. Whilst the excavations have been carried on in a very systematic manner, several very valuable hot and cold springs that supplied the baths have been rediscovered. As can be seen by (Pl. XV.) they were very extensive with several large swimming basins, sudatoriai, as well as small baths. The rooms were lined with Carrara marble and decorated by statues, the uncovering of one of which is shown in the photograph. The numerous lead pipes, stop-cocks and other hydraulic apparatus are remarkable, whilst, the Thermae were traversed (see plate) by a well paved road, a branch from the ancient Via Domitiana. At this point the Garigliano was traversed by a bridge, the piers of which are still visible. Unfortunately these ruins will all disappear in a few years in consequence of the metamorphosing action of the mineral waters ; the bricks have even lost their red tint and disintegrate into a slate-coloured earth, whilst every kind of stone employed by the builders is more or less corroded and when exposed to weathering rapidly crumbles to pieces.

The actual extent of these baths is not known but what

has already been uncovered is very considerable. It is not unlikely that these springs will prove to be the richest in the district but so far they have not been analysed.

As we proceed further northwards, other springs are encountered but they are cold sulphur waters very similar to the rest, the last of importance being called the Acqua di Salomone which drives a mill of that name.

Crossing the river at the ferry (Scafa di Mortola) and retracing our steps along the opposite bank of the river, we quit the road just before reaching the point opposite the Stabilimento Provinciale and ascend a mountain path to the great tunnel quarries above described and close by enter a narrow gorge, which soon is interrupted by a precipice over which the water, from the mountain above, falls in a small but elegant cascade forming a sylvan scene of rare beauty. Close at hand on our right as we stand and admire the fall we notice an ochre coloured stream that issues under the cliff. On examination we find a small archway or tunnel at the foot of the precipice some 30 or 40 cm. high and of twice the breadth, in which constantly rises a jet of cold iron water with a series of dull bumps and gurgles, forming a small basin from which the overflow runs as a rivulet to join the main stream of the gorge. This water as will be seen by the analysis is a fine specimen of a gaseous chalybeate character, very pleasant to the taste and not overcharged with iron.

Returning to the river banks, we find a bare space amongst the rich vegetation composed of a yellowish earth with blocks of lava, in the middle of which rises a fountain of gas surrounded by a small hollow or basin, which, when filled with water, this latter is kept in a violent state of agitation resembling a small continuous geyser, the column often rising 1m. or more high.

This "solfione" represents an enormous escape of gas which is comparatively cool so that the water is at the most tepid. Close at hand are several "mofete" on a large scale, some of which almost should be considered Solfatare besides several warm and cold sulphur waters of great volume.

The mineral waters of Sujo are remarkable for their abundance and especially for their gaseous components. Iodine waters are rare all over the world especially ones as rich as that of the Stabilimento Provinciale. Equally important are the springs in their variability of temperature and strength so as to suit them for the most variable applications of drinking or bathing. Their chemical composition can be judged of from the 4 analyses by Prof. Casoria here appended. Another point is the possession of a good iron

water which is of so much use internally combined with baths of sulphur water. Lastly their quantity is practically unlimited for no less than five mills are driven by an equal number of streams of mineral water from springs.

ANALYSES OF SOME OF THE TYPICAL WATERS OF SUJO

PER LITRE .	Acqua dello Stabili- mento Provinciale	Acqua Caselle (Posto Ban- one)	Acqua Caselle (drinking water)	Acqua Ferrata di Catafri
H_2SO_4	0·410646	0·190900	0·112602	0·004463
H_3PO_4	0·007504	0·002533	0·001419	trace
CO_2	0·611600	0·779790	0·993800	0·718630
SiO_2	0·053200	0·045000	0·041000	0·198000
I	0·087200	—	—	—
Cl	0·045970	0·046975	0·033300	0·095162
CaO sol. after boiling	0·010080	0·014560	0·012320	0·020840
CaO insol. after boiling	0·506842	0·590640	0·473760	0·041140
MgO sol. after boiling	0·121910	0·129813	0·062237	0·016357
MgO insol. after boiling	0·077398	0·092257	0·087863	0·007463
Al_2O_3	0·006000	0·003000	0·000038	0·017010
FeO	0·000677	0·002700	0·000953	0·027619
MnO	trace	0·001300	0·001000	—
K_2O	0·071570	0·064997	0·049798	0·396800
Na_2O	0·173169	0·069416	0·129900	0·068670
H_2S	0·013650	0·041500	0·458200	—
Dissolved air	—	0·284504	—	0·064660
BaO	{	SPECTROSCOPIC TRACES	{	{
SrO				
L_2O				
Organic matter	trace	trace	trace	trace
Solid residue per litre	2·280	1·980	1·400	1·120
Temperature	37° C.	29° C.	27·5° C.	21·5° C.
Sp. G.	1·0029	1·00294	1·00214	1·00014

Prof. CASORIA

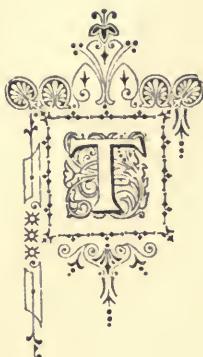
The fine air, the beautiful scenery, and the many interesting phenomena and objects of the neighbourhood, combine to render this site one of the most favourable ones for a Spa. Close at hand we have several ruins of cyclopean walls, Roman buildings, feudal castles and other antiquities, and strange freaks of nature, one being a stalactite cave, of great beauty, close to the two establishments. This cave of unknown length we explored for a considerable distance. Its walls are draped by elegant stalactites and calcareous fringed curtains of great beauty.

So far, four hours of diligence and one hour of mule-path rendered this health resort inaccessible to nearly everybody but the local peasantry, some 2000 of which resort to it each season. Nevertheless the salutary effects of the waters have drawn others to it and De Sanctis when Minister signed numerous decrees in a straw hut built against a rock close to the Stabilimento delle Quattro Torri. Now these unfavourable conditions have already in great part disappeared. The railroad to Gaeta will leave passengers at the Station of Castelforte and in half an hours drive will bring one to either of the establishments. It is thus placed within easy and commodious reach of both Rome and Naples.

The only remaining thing required to place this amongst some of the best Spas of Europe is a good hotel and several little baths over those springs intended for such. It is extremely doubtful if Sujo will ever attain widespread renown as a Spa, unless it is organized on a grand scale for the higher class of invalids, as so numerous are second-rate establishments that have already attained eminence that a new rival must far surpass them to draw to itself a multitude of visitors. While Italy is more than well supplied with second rate thermo-mineral stations it is particularly poor, if not entirely unprovided with first-class ones and this is a fine opportunity to endow the country with one at Sujo.

The kind invitation on the part of the provincial council of the Terra di Lavoro to the Geologists' Association to visit Sujo was very gratefully received but time and a pre-arranged program prevented the party from accepting it. Dr. Sambon and myself are both most grateful to Prof. Spatuzzi and Signori d' Orvè, Cimino and Duratorre for kind hospitality and help in our subsequent visit to the locality.





CHAPTER VI.

THE TRAVERTINE AND THE ACQUE ALBULE IN THE NEIGHBOURHOOD OF TIVOLI

By Signor PIETRO ZEZI

Mining Engineer and Secretary of the "R. Comitato Geologico" of Italy.

Camongst phenomena of volcanic origin, which may be observed on a grand scale on the meditteranean slopes of central Italy, meriting special attention is the formation of travertine or limestone due to chemical precipitation, and named from the latin *Lapis tiburtinus* or Tivoli stone.

This phenomenon, which in the first owes its origin to volcanic activity, not yet entirely exhausted in this part of Italy, may be met with in various localities of the province of Rome: amongst these the most important for its extent, its position, and its history is that in the vicinity of Tivoli on the plain known as that of the Acque Albule (*piano delle Acque Albule*) from a very large spring of sulphuro-calcareous water found there.

The relationship which exists between the travertine and so called secondary volcanic action is well known. The gaseous emanations of volcanoes in their major state of activity, such as hydrochloric or sulphurous acids, etc. in proportion as the activity diminishes give place to sulphuretted hydrogen and carbonic acid. The consequence is that subterranean waters circul-

ating in volcanic regions, which are in the last stage of the activity of endogenous forces, as it traverses limestone rocks dissolves them by forming a bicarbonate which subsequently is deposited immediately on coming in contact with the atmosphere, when the bicarbonate is decomposed, with great evolution of free carbonic acid. Such deposits when continued for long periods of time give rise to the formation of beds of travertine; and the locality where this takes place by preference is at the foot of valleys and specially where these spread out forming lacustrine basins.

Such in fact is the condition of the plain in question which was the bottom of an ancient quaternary lake fed by the river Aniene flowing down from Tivoli, and bounded on two sides by the Monti Tiburtini and Cornicolani, composed of liasic limestone, and on the other two sides by pliocene and quaternary deposits of the volcanic tableland of the Campagna Romana. It was in fact in this very lake that besides the waters of the Aniene, there were copious calcareous springs coming from the surrounding high mountains and depositing the carbonate of lime held in solution on the lake bottom.

The remains of such large springs in fact, are to be seen, in the actual Acque Albule and in a few other instances of the kind which appear just in the central part of the old lake, now completely filled by the travertine, and around the edges by the detritus brought down from the surrounding mountains.

The epoch at which the great beds of travertine were formed, was in part contemporaneous with, and in part immediately posterior to, the deposition of the quaternary volcanic tuffs of the Roman Campagna. Nevertheless travertine continued to form at a later date in the higher parts of the basin as this continued to become more contracted in consequence of either the diminution of affluent waters or a freer drainage of the lower valley. However, such, travertine, which we may call recent, occurs to limited extent and furnishes a material which is more cavernous in structure with abundance of incrusted vegetable remains and in consequence less adapted for employment as a building stone capable of being dressed. It is therefore evident that the deeper the point from which the Travertine is taken and the greater the age of its deposition, the purer and more compact it is. Even at the present time the spring of the Acque Albule forms deposits of the so called tartar (*tartaro*) or spongy travertine and the drainage canals would soon become choked were it not for continual cleansing to maintain them in activity.

The geologist who makes a visit in detail to the plain of the Acque Albule will observe that the deposits of travertine there occur in great horizontal beds at relatively different levels forming so many terraces or steps, the lowest of which forms a smaller ring or circle than those that stand at a higher level. One can count several of these more or less concentric circles diminishing in size; they evidently indicate the successive stages lowering of the surface of the water lake of the.

The fossil remains which are found in the travertine above, all denote an exuberance of vegetation on the shores surrounding the lake. Different willows, oaks, elms, beeches and conifers have left numerous imprints of their leaves in the travertine; and land and fresh water shells abound, neither are freshwater crustacea absent, besides tortoises, birds, and numerous remains of mammalia such as horse, deer, sheep, goat, ox, in some cases human bones have even been met with.

As has already been mentioned the only vestige of the ancient calcareous springs is that of the Acque Albule which flows forth near the middle of the grand basin forming a small lake, known as Lago della Regina, of elongated form, 230 m. in circumference and 36 m. in depth. This little lake is always full of limpid water of a dirty azure tint, that is in lively ebullition from the constant escape of gas principally composed of carbonic acid and of sulphuretted hydrogen. The water has a constant temperature of about 22° C. and holds in solution a very considerable quantity of carbonate of lime together with sulphate of lime, chloride of sodium, chloride of magnesium, sulphate of magnesia and traces of oxide of iron.

The water, at first limpid, becomes turbid when exposed to the air and assumes a white milky appearance in consequence of the liberated sulphur, from the decomposed sulphuretted hydrogen, hence its name Acque Albule. Besides the abundant calcareous deposits in the lake there are also there formed little concretions of sulphur which give a yellowish tinge to the calcareous incrustations.

In the same manner little concretionary masses, which remain floating on the surface of the lake, are formed from carbonate of lime surrounding organic matter of vegetable origin.

The outflow of water from the spring is more than 270000 m. cub. per diem, which corresponds to about 314 m. cub. per second, an outflow that is really enormous and is such that it gives rise to quite a little river. The quantity of solids contained

in this water has been calculated at about 700 kg. per diem and therefore more than 300 tons per annum.

Near the Lago della Regina there exists another small lake at a slightly higher level called Lago delle Colonnelle, with a depth of 57 m. and supplied by a spring similar, but much smaller in proportion, to the preceding into which it empties itself by a canal. From the opposite extremity of the principal lake starts a canal about 4 m. broad, known as the Canale dell'Acqua Zolfa, which was constructed by Cardinal d' Este to improve the salubrity of the region. By this canal the water from the two lakes is conducted to the Aniene after a course of about 4 km. and with a total fall of a good 25 metres.

The waters are extensively used for baths and there is a large bathing establishment constructed near the Via Tiburtina, with a railway station on the Rome & Tivoli line. They also, the incline being steep, furnish as a motive power for a saw-mill and a grain-mill. As a consequence of the great velocity of the outflow, the major part of the carbonate of lime together with the suspended sulphur to which, as has been said, its white colour is due, is carried into the Aniene, thence to the Tiber and finally to the sea. It is a difficult matter to calculate the amount of solid matter thus carried into the sea; it may be estimated at 200 tons per annum if we suppose one third to be deposited in the lakes and lost along the road.

In conclusion, a few data relative to the uses of travertine and its quarries may be usefully given.

Of all the materials of the neighbourhood of Rome, the travertine is that which lends itself best to building purposes of importance, both on account of the ease with which it may be worked, for its appearance and durability. Mechanical tests prove it to be one of the most tenaceous of limestones.

The *lapis tiburtinus* was one of the most characteristic materials of ancient Roman buildings. Little used in the time of the kings and of the republic on account of the difficulty in working it compared to the volcanic tuff, it was much more extensively used during the empire; amongst some of the principal works that are still to be seen, the Coloseum, the Theatre of Marcellus, the

* This is no doubt due to the absence of vertical cleavage cracks either visible or otherwise, whilst the knitting together in a horizontal plane render it able to resist vertical fracture and surface weathering whilst loose flat slabs can be easily cut. Ed.

Ponte, Elio, Temple of Fortuna Virile, the Arch of Drusus, etc. may be mentioned.

The Romans only obtained the travertine from some points along the right bank of the Aniene, in the valley of the Ponte Lucano, at the locality now known as Barco, after a hamlet existing there. The space left by the enormous quantity of material that was removed has been calculated at about 5 or 6 million of cubic metres. There remains near the banks the Aniene an accumulation of detritus forming some small hills as much as 20 m. above the plain of the quarries.

The state of good preservation in which ancient edifices built of travertine remain, demonstrate the valuable qualities of the stone. In consequence it was extensively used for buildings in the middle ages and modern times, particularly in the large churches, *palazzi*, fountains, etc., amongst these may be mentioned the basilica of S. Peters, St. John Lateran, the Trevi fountain, as well as the *palazzo* of the Cancelleria, etc.

The travertine lends itself fairly well to statuary and many examples are to be seen in the facades of churches and some *palazzi*, in the colonnade of the *piazza* in front of S. Peters, in the large fountains, etc.

The quarries which, till quite recently, furnished nearly all the travertine for medieval and modern construction in Rome were those known as the Caprine and Fosse, both situated laterally and not very distant (from 1 to 2 km.) from the Lago della Regina, the ancient ones of the Barco of the Roman period having been abandoned. It was from the Fosse opened out about A.D. 1500 that the material necessary for the construction of the Basilica of St. Peters was derived.

Of late years, in consequence of the extraordinary increase in building, especially in Rome, particularly for bridges and the embankment of the Tiber, new quarries have been started at the Villa Adriana, below Tivoli, at the eastern extremity of the basin, whilst the great Roman quarries of Barco have been reopened.

The annual total output of the group of quarries at present being worked may be estimated at an average of 4000 cub. m. of which two thirds are employed for buildings in Rome and the rest for the works along the Tiber.

The ordinary price of this material in Rome is 80 Lire It. or about L. 3,, 0,, 0 the cubic metre for blocks not exceeding 1 cub. m., but of course, proportionally higher for blocks of greater volume. When it is cut into slabs of 7 to 10 cm. (or 3 to 4 in.) the price of the cubic metre rises to 180 Lire It. or about

L. 7,,0,,0: The cost of columns and other similar architectural works in a single piece, varies according to the amount of labour necessary and may be considered to average in general 200 to 300 L. It. per cub. m. or about L. 8,,0,,0. to L. 12,,0,,0. For a complete statue of the height of 2 m. the average cost may be put at Lire It. 4000 or Lst 160,,0,,0. (For further details on these points the following works may be consulted: N. PELLATI, *I traverlini della Campagna Romana*, Roma, 1882, and L. DEMARCI, *I prodotti minerali della provincia di Roma*, Roma, 1882.





CHAPTER VII.

BIBLIOGRAPHY

of

THE GEOLOGY AND ERUPTIVE PHENOMENA

OF THE SOUTH ITALIAN VOLCANOES

THAT WERE VISITED IN 1889

AS WELL AS OF THE SUBMARINE VOLCANO OF A. D. 1831.

Compiled by

MADAME ANTONIA F. LAVIS AND D.^r H. J. JOHNSTON-LAVIS

The constant progress of geological and vulcanological research in this interesting region is marked by the appearance of numerous memoirs and notes, many of which are published in proceedings of learned societies and often are overlooked or are unknown to other workers at the same subject. In 1881 the committee of organization of the International Geological Congress undertook the production of a Geological and Paleontological Bibliographical list of Italy. For many unavoidable reasons that list was an imperfect one, besides which during the last ten years a great number of new studies have been published. It was therefore thought advisable to place before the geologists who

visited this region a fairly complete bibliography which may be a requisite should they or others be tempted to study any of the districts. In undertaking this compilation we had little comprehended the difficulties and the very long and tedious work necessary to bring it to a fairly successful termination.

The subject has been divided according to the different volcanic groups, and where a book or memoir describes more than one such, the title is found repeated in the separate divisions concerned. The last district is that of the volcanic group of the Alban Hills, to which we do not pretend to give a complete bibliography for the following reasons. We possess no intimate acquaintance with its literature, nor is it possible to easily divide this one from the volcanic district immediately to the N. of Rome, and finally the ground has been already covered by the important publications of a similar nature by Signor B. Contarini, Prof. R. Meli, Signor P. Zezi and others.

Of Roccamonfina and its neighbourhood we believe this is the first separate list of works referring to that volcano that has appeared.

The region, generally known as the Campi Phlegræi, is one that is as yet but little understood so that each year numerous additions are made to the literature of a district as classic from a vulcanological as from a historical point of view. Many older publications bearing thereon have been added, so that the list has been much lengthened as well as a considerable number of corrections of errors have been made.

In regard to Vesuvius we cannot do better than quote the words of Comm. L. Riccio as follows. — "The eruptive period that commenced on Dec. 16th 1631 had not terminated when already V. Bove at pp. 47 and 48 of the pamphlet published by Mormile, gave the first list of no less than 56 published accounts on that occasion. A few years after Ferrante Bucca recorded a much more important and numerous catalogue. During the last century various authors considered it of use to publish lists, especially of the 1631 eruption of Vesuvius, as Majone (1703), Lasor a Varea (*Savanarola*) (1713), Morhof (1714), P. G. M. della Torre (1755), Ab. Galiani (1772), Vetrani (1780), Soria (1781), Giustiniani (1793) and Duca della Torre (*Senior*) (1796); and in the present century Scacchi (1847), Palmieri (1859), De Blasiis (1875); and again Scacchi in 1883." To these we may add L. M. Greco, J. Roth the price lists of books by G. Dura, Napoli, 1866, F. Furchheim (1879), and Hoepli, Milan, 1879.

It is however to Comm. L. Riccio that so much is due. In the

first place, his untiring exertions during many years, has resulted in the bringing together of the most complete collection of works generally referring to Vulcanology and Seismology and especially to Vesuvius and the other Neapolitan volcanoes which is now deposited in the rooms of the Neapolitan Section of the Italian Alpine Club. The foundation of this splendid library consisted of about 2000 books and pamphlets belonging to the celebrated French seismologist Alexis Perrey. By Signor Riccio's exertions the number is at present raised to about 7000, amongst which are many valuable manuscripts. Unfortunately this unique library is practically lost, for the difficulties of getting at the books for study are so great that the most diligent is prevented from succeeding. We also owe much to Cav. L. Riccio for searching out manuscripts relating to Vesuvius that are stored in other libraries, and many of which he has had copied or has published with suitable comments. The Vesuvian bibliography published in 1881 is the work of Signor Zezi and contains 650 titles. The list we now present is much more extensive, a considerable portion of which has been obtained from the catalogue of the Alpine Club library.

For bibliographical lists of Etna, we are indebted to P. G. A. Massa, Sartorius Von Waltershausen, Von Lassaulx, and O. Silvestri the latter bringing the lists up to 850 entries. That catalogue however, includes besides the province of Catania, which we here have eliminated, the Lipari Islands, of which we have made a separate list, adding much new material, as also with that of Graham's Island.

No doubt there still remain a considerable number of omissions, and not a few errors and unperfections which we shall be very grateful to have communicated to us, and which will be either utilized by us in some future edition or transmitted to some other competent persons, as future circumstances shall decide.

Abbreviations

(B. N.) Biblioteca Nazionale di Napoli.

(O. V.) Osservatorio Vesuviano.

(C. A.) Club Alpino, Sezione di Napoli.

Where no distinct name of an author or responsible editor is to be found in a publication, it is catalogued under the title of ANONYMOUS where it is arranged according to the actual or

presumed date of its publication. Those works without dates are placed in alphabetical order at the end. The same system is adopted with the different publications of any one author, but when a memoir is written by two or more persons, the title is put at the end of the list of the first author's works.

The lists include also earthquakes where these appear to be of a volcanic nature or limited to the immediate vicinity of a volcanic district. The number of our additions may be judged of, by comparing the catalogue prepared by the International Geological Congress of 1881 with the present.

<i>Int. Geol. Cong.</i>		<i>Present list</i>
739	{ Lipari Island 119 Grahams Island 28 Etna 880	}
667	Vesuvius	1552
290	{ Campi Phlegræi 539 Roccamonfina 33	572
125	Alban Hills.	210
<hr/>	Total	<hr/>
1821		3361

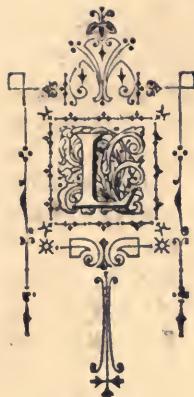
Finally we have to thank Dr. L. Sambon for several additions and help in many ways as also to Prof. F. Borsari. Our thanks are likewise due to Mr. F. Furchheim who has kindly corrected the German and to Conte de la Ville for aid in our bibliographical search.

RECENT
TOPOGRAPHICAL AND GEOLOGICAL
MAPS, CHARTS, PLANS, AND MODELS
OF THE
SOUTH ITALIAN VOLCANOES.

1. CARTA (CARTOGRAFICA) D'ITALIA — 1:1 000 000, in 7 sheets. 3 editions. 1st in three colours with the mountains shaded in brown and water in blue, 2nd mountains in grey, 3rd without mountain shading. See sheets 3 (part of Alban Hills) 4 (part of Alban Hills, Roccamontefina, Campi Phlegræa, and Vesuvius). 6 (Etna, and Lipari Islands). — *Istituto Geografico Militare Ital. 1889.*
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3. CARTA COROGRAFICA DEL REGNO D'ITALIA E DELLE REGIONI ADiacenti — 1:500 000, in 35 sheets. 3 editions. 1st in three colours; 2nd in two colours; 3rd in black, without mountain shadeing. See sheets 18 (Rome), 24 Naples and Vesuvius, 29 Lipari Islands, 34 Etna. — *Ibid. 1889.*
4. CARTA DELLA SICILIA — 1:500 000, in 1 sheet. In black; mountains shaded. Includes Etna and Lipari Islands. — *Ibid, 1885.*
5. CARTA TOGRAFICA DEL REGNO D'ITALIA — 1:100 000, in 277 photo-engraved sheets, in course of publication (1889). The orography is shown by contour lines of 50 m. as well as by zenith-light shading. See sheets 150 Alban Hills; 160, 161, 171, 172 Roccamontefina; 183, 184 Ischia and Campi Phlegræi; 184 185 Vesuvius; 261, 262, 269, 270. Etna; 244 Lipari Islands. — *Ibid.*
6. CARTA TOPOGRAFICA DEL REGNO D'ITALIA — 1:100 000. Chromolithographic edition in three colours without line shading of mountains. Same divisions as last. — *Ibid. 1889.*
7. CARTA TOPOGRAFICA DEL REGNO D'ITALIA — 1:75 000. Economic edition similar to N.^o 5.

8. CARTA TOPOGRAFICA DELLA LOMBARDIA, DEL VENETO E DELL'ITALIA CENTRALE — 1:75 000, in 159 half sheets. Mountains shown G 15, H 15, G 16, H 16 (Alban Hills); — *Ibid. 1829-1889.*
9. TAVOLETTE RILEVATE PER LA COSTRUZIONE DELLA CARTA DEL REGNO D'ITALIA — Part to the scale of 1:50 000 and part 1:25 000. See sheets 150 I-IV (1:25 000) (Alban Hills). 160, 161, 171, 172 I-IV (1:50 000) (Roccamontfina); 183 II, 184 I-IV Ischia and Campi Phlegræi. 184 I-II. 185 III-IV (Vesuvius); 244 I-IV (Lipari Islands); 261, 262, 269, 270 (Etna); All 1:50 000 — *Ibid. 1873-1879.*
10. CARTA TOPOGRAFICA DI ROMA E DINTORNI — 1:100 000, in 1 sheet Similar to N.^o 5. Alban Hills. — *Ibid. 1883.*
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GRAHAM'S ISLAND
ISOLA FERDINANDEA
OR
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for "verdi" "read rossi" i. e. for "green" read "red.")*
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ANONYMOUS. — Giornale dell'incendio del Vesuvio dell'anno 1660. Con le osservazioni matematiche al molto illustre e molto eccellente signor mio Padrone osservandissimo il Signor D. Gius. Carpano Dottore dell'una e dell'altra legge e nella sapienza di Roma primario professore. A. C. — *Roma, 1660.* (*This is the Roman edition of the other two articles under the head of "Anonymous" referring to the erupt. of 1660. The author was padre Supo as proved by a M. S. See Supo. P.* (O. V.).

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ANONYMOUS. — Nuova istoria di una grazia particolare ottenuta da Dio alla città di Napoli, per intercessione di Maria Ss. ed il glorioso S. Gennaro per il Terremoto sortito la sera dei

12 Giugno, e la grand eruzione del Monte Vissuvio la sera de' 15 del sudesto mese; giorno di Domenica alle ore 2 della notte del 1794. A qual' effetto allagò di foco molti villaggi intorno stendendosi sino al mare con rovinare la gran Terra della Torre del Greco. — ?, *in 12.* (B. N.).

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7	— 23.	broom, brush.	broom bush,
26	— 18.	Vesuvian	vesuvian
33	— 15.	Cavaliceri	Cavalieri
34	— 14.	Count G. T.	Count G. S.
47	— 7.	conclusion	conclusions
»	— 19.	adition	addition
»	— 21.	conferm.	confirm
48	— last	consequitive	consecutive
49	— 36.	constituent.	component
51	— 28.	varietes.	varieties
55	— 36.	in.	is
59	— 3.	More recently	More recently
»	— 13.	obsi-dian	obsidian
»	— 15.	i.	is
»	— 15.	at.	as
60	— 31.	cratnric.	crateric
61	— 40.	varietes.	varieties
62	— 35.	Liparites	Lipariotes
63	— 1.	hygrometric	hygrometric
»	— 14.	Do know you	Do you know
64	— 8.	wither	whither
67	— 5.	thuunder	thunder
»	— 8.	set	(omit)
»	— 16.	censequence	consequence
68	— 13.	workes	working face
»	— 23.	threathen	threaten
69	— last line of note —	encountred	encountered
71	— 32.	behinwen	behind, when
73	— The note at bottorn of page to page 74		
74	— 33.	Else, where	e'sewhere
78	— 38.	Authorités	authorities
80	— 18.	precipe	precipice
82	— 2.	inaccessibile	inaccessible
84	— 19.	time	lime
85	— 8.	lake of the	of the lake
86	— 31.	limestones.	limestones *
91	— 7.	looks.	brooks
»	— 13.	Cav.	Comm. ^e
»	— 21.	endebted	indebted
»	— 29.	he	be
93	— 1.	an	and



Johnston Davis Phot.

Danese Reprod.

THE CRATER AND THE "SCIARRA" OF STROMBOLI. JUNE 1887.

Plate II.



Johnston: Lava Phot

Danesi Reprod.

RIDGE ABOVE CRATER, CRATER AND COMMENCEMENT OF THE "SCARRA" OF STROMBOLI SEEN FROM THE W. SIDE IN JUNE 1887.

Plate III.



Johnston-Lewis Phot.

Dane's Reprod.

CRATER OF STROMBOLI SEEN FROM W. SIDE DURING AN EXPLOSION SEPT 19TH 1889.



Collected by

James Reprod.

AN EXPLOSION FROM CRATER OF VOLCANO AS SEEN FROM CONCEPCION, CHILE, FEB. 14TH, 1889, 45 P.M.



FIG. 5.—Specimen No. 1000, from the same exposure as Fig. 4, showing a large fragment of a rock containing numerous small fragments of quartz.

FIG. 6.—Specimen No. 1001, from the same exposure as Fig. 4, showing a large fragment of a rock containing numerous small fragments of quartz.



Plate VI.



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SAME AS LAST WITH COMMENCEMENT OF EXPLOSION.



LEAVES OF CAPTAIN'S OR CROWNED STAR.

Plate VIII.



Fig. 10. - Pl. 9

Fig. 10. - Pl. 9

THE EXPLOSION AT LAST ABOUT 10 SECONDS AFTER.



July 22nd - 2pm

Afternoon

ERUPTION FROM VULCANO AS SEEN FROM THE END OF THE PLATEAU
OF THE ISLAND ON JULY 22nd 1863.

Plate X.



1000 feet. High

1000 feet. Low

SAME EXPLOSION AS LAST ONE MINUTE LATER.

Plate XI.



CONE OF VULCANELLO WITH S.S. "VILLA SAN GIOVANNI" SEPT. 23



G. J. Eunson Phot.

D. A. D. Repd.

BREAD-CRUST BOMB EJECTED FROM CRATER OF VULCANO AND STILL
HOT ON SEPT. 21ST 1889, ON PLAIN N. OF CONE



Plate XII



Johnston-Lewis Phot.

Danesi Reprod.

GLOBULAR BASALT UNDER CASTLE OF ACI-CASTELLO



Johnston's Plate

Plate XIII

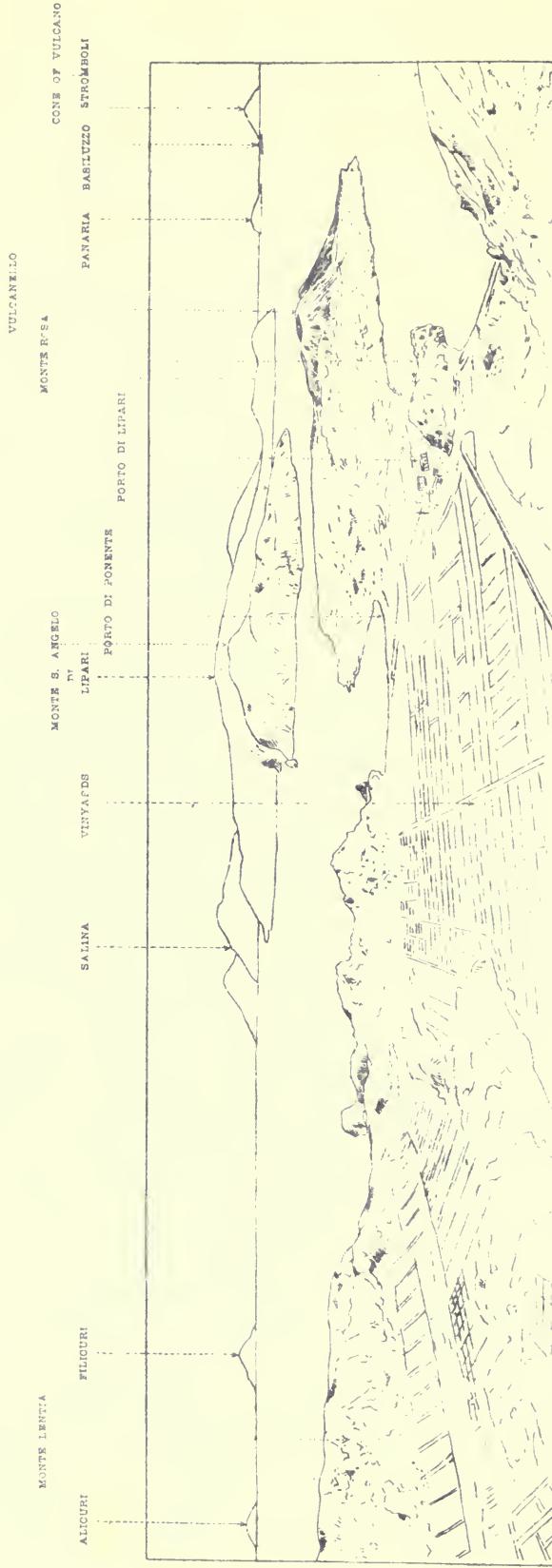
Planaria hebrid.

Plate XIV.

HOUSES AND FACTORY
OF M. SARLIER

MONTE DELLA GUARDIA
DI LIPARI

VARAGLIONE
PORTO DI LEVANTE



DANESI LITH.

PANORAMA OF THE LIPARI ISLANDS AS SEEN FROM THE NORTHWEST OF THE CRATER OF VOLCANO VULCANELLO

FROM A PANORAMIC PHOTOGRAPH BY H.J. JOHNSTON-LAVIS
1882

Plate XV.



Johnson - Davis Phot.

Danesi Reprod.

RUINS OF ANCIENT ROMAN BATHS OF SUJO

MAY 1891

Plate XVI.

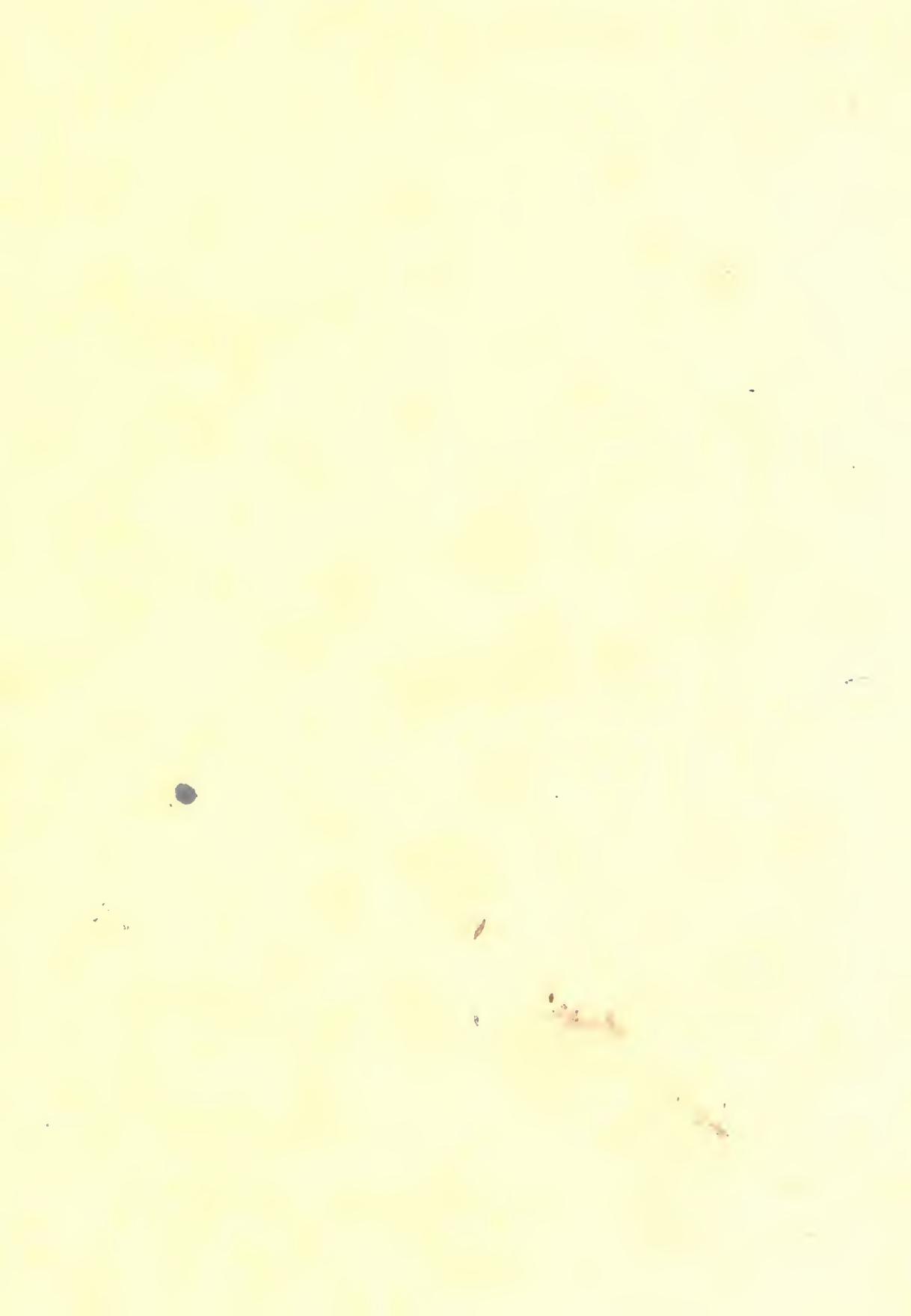


Johnson-Wayne Phot.

Danesi Reprod.

ACQUA CASELLE BELOW THE STABILIMENTO DELLE QUATTRO TORRI OF SUJO

MAY 1891



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